Report on the Agricultural Experiment Stations, 1953

UNITED STATES DEPARTMENT OF AGRICULTURE

Office of Experiment Stations

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REPORT ON THE AGRICULTURAL EXPERIMENT STATIONS, 1953 [1]

By R. W. Trullinger, *Chief, Office of Experiment Station,* in collaboration with the technical staff

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FARM PROGRESS THROUGH STATION RESEARCH

The welfare of modern society is intimately interwoven with man's dependence on scientific research. Research seeks to establish, beyond any element of doubt, the facts and truths on which we may rely to preserve our health, develop our resources, and to solve those problems that stand in the way of human advantage and achievement. The quality of research and the integrity of the institutions that foster it and engage in it serve as yardsticks for measuring the current soundness and future stability and progress of a people.

To serve society, the structure of research needs to be closely integrated with the needs and problems of the people it is intended to serve. The State agricultural experiment stations are an important segment of this structure. The State stations, in close cooperation with the United States Department of Agriculture, industry, farmers, farm organizations, other scientific institutions, and scientific societies join in a nationwide cooperative research system for agriculture. The scientific findings growing out of this system are the source of the progressively improving techniques and efficiencies employed by farmers in their individual farm enterprises whose goal it is to meet

[1] Issued January 1954. Submitted in accordance with the requirement that the Secretary of Agriculture shall report to Congress on the work and expenditures of the State agricultural experiment stations established under the Hatch Act of 1887 and supplementary legislation. The period covered is the fiscal year ended June 30, 1953.

the expanded needs of the population and a growing industrial economy.

The scope of the State experiment station program is indicated in table 4 showing the sources of funds for station research in 1953, a program on which a total of nearly 62 million dollars representing non-Federal funds, composed largely of State appropriations and other funds of non-Federal origin, was expended.

The business of the research scientists at the State agricultural experiment stations is to develop new facts and principles useful to farmers. Great differences in climate, soils, and topography exist among the States. Such differences present specific, localized problems. The diversified interests of farmers, influenced by such factors as location, available markets, and the individual farmer's ability to produce efficiently, also require individualized research solution from State to State.

One cannot separate pure or background research from that which is termed applied or practical research. Applied research is dependent upon background studies, the findings of which may be put to practical use. Whether research is basic and fundamental or practical and applied, the emphasis in agricultural experiment station research is on the systematic, scientific study of problems facing the operating farmer, and the practical solutions to these problems.

Agricultural Research and Livestock Production

Good eating in the United States calls for an adequate supply of animal protein such as is supplied in meat, eggs, and milk. For this reason livestock production has become one of the Nation's major production enterprises. In 1952 the value of livestock products, including poultry, amounted to 56 percent of the total cash income of the American farmer.

Many specific lines of research have contributed to the extensive expansion of livestock production. For example, the practice of animal husbandry has been greatly advanced by biochemical researches. Today every farmer knows that nutrition has a direct bearing on animal health and production. At the turn of the century experiment stations placed great emphasis on the improved feeding of livestock as a means of obtaining greater profit in the production of milk and meat. Leaders in this field took a prominent part in bringing about passage of the Adams Act of 1906, under which Federal-grant funds are made available to State experiment stations for fundamental research.

One of the first experiments launched under this act was the famous Wisconsin study of feeds and feeding as they affect the growth and development of animals. Out of that initial experiment and numerous similar ones at the Wisconsin and other experiment stations grew the vast amount of knowledge used in today's science of animal nutrition. In these experiments, scientists first employed small animals with a short life cycle, such as rats and mice, to test principles that could be applied equally or similarly to the slower-growing larger animals of the farm. Later findings led to the discovery of vitamins and to subsequent investigations of the protein fractions and other factors that have much to do with animal growth and health. Many of the discoveries subsequently found practical application in the

sciences concerned with human nutrition and health. Today there is no letup in the intensive and systematic search for the solution of many unsolved problems.

LIVESTOCK PRODUCTION AS AFFECTED BY ANIMAL DISEASES

One of the greatest handicaps to efficient farming is the problem of animal diseases. Because we cannot afford to live with such diseases, State agricultural experiment stations and the U. S. Department of Agriculture have been conducting a concentrated research drive on this problem. Much has been done in developing helpful forage and feed production practices and new and better feed crops; in eliminating poisonous plants from ranges and pastures; in finding new and more economical methods of feeding; in developing better breeding practices; and in increasing the general knowledge about animal physiology and in fields related to successful livestock production.

There is no way of telling accurately the actual economic losses to animal production as a result of disease, parasitism, or various abnormal conditions. Such figures as are released from time to time are only estimates. They indicate that animal disease presents a major economic obstacle that must be hurdled before the ever-increasing demands for meat and livestock products are met.

Two interesting sample estimates follow: The first, released in a North Central Region publication, "Facts About Newcastle Disease," indicates an annual loss of $40,000,000 to the poultry industry as a result of Newcastle disease. This figure is broken down into death losses, losses in gain in weight and egg production, and vaccination costs. The second, released by the Indiana station, states that, "animal agriculture during 1951 failed to realize a potential gross income of $2,791,000,000 as a result of death losses alone." It further pointed out that these staggering losses do not include decreased income due to lowered production, stunted growth, or inefficient feed utilization resulting from many diseases that are not ordinarily fatal to animals.

Maintenance of Animal Health

Advances in the field of animal health have been greatly enhanced by the cooperation of veterinarians with other agricultural specialists. At a number of the experiment stations a close integration of all veterinary research in the different animal and biological departments has been brought about. By using the know-how and tools of participating specialists in other fields and cooperating with them, the veterinarians have been able to broaden their studies and to more rapidly establish and publish findings of fundamental importance concerning the maladies affecting livestock. Thus the veterinarian may find himself teamed with the nutritionist, geneticist, agronomist, biochemist, soil specialist, agricultural engineer, livestock production specialist, and others.

Summary statements in the first part of this report deal with specific problems and announce results that experiment stations have reported. Although the animal science departments have been leaders in much of this research, they have also had the close cooperation of their col-

leagues in many related fields of study. The results of this coordinated type of endeavor may be illustrated by the following examples selected from various fields of agricultural research as they apply to animal health, and by several that are in the conference or planning stages.

Hormonal Balance and Animal Health

Maximum inherited growth in a healthy animal is attained only when there is a proper balance between the food nutrients he receives and his endocrine secretions. Since an animal's environment is never free of pathogenic organisms, certain immunity factors or perhaps antibiotics are essential. The Michigan station has found that either a marked excess or deficiency of a particular hormone in the animal body may increase the need for certain dietary factors. For example, the administration of large doses of cortisone, diethylstilbestrol, or iodinated casein to young rats was shown to aggravate pre-existent deficiencies of vitamin B_{12}, thiamine, or pyridoxine. This was evidenced by decreases in body growth, survival rate, and in earlier manifestation of other typical deficiency symptoms. Supplementation of the deficient diets with 5 to 10 times the normal requirements for these vitamins or with small amounts of antibiotics largely counteracted the deleterious effects of hormone overdosage, and was accompanied by increased food intake and greater efficiency in converting food into body weight gains.

Many other examples might be cited, but the Michigan scientists stress the fact that this information was obtained by experimentation with laboratory animals and is of a preliminary nature. Results to date indicate that many of the conflicting reports on methods of combating diseases of farm animals can be explained and a vast amount of valuable new information can be gained by combining the efforts of the physiologist, the biochemist, and the animal husbandman.

Diseases of Cattle

Reproductive disorders

Knowledge of factors involved in reproductive disorders of cattle is limited, but their causes are numerous and complex. Dairy scientists at the Washington station have been making detailed observations on the reproductive history of 10,000 gestations of a large Holstein herd. In an analysis of breeding records to determine the effect of some 46 reproductive disorders on breeding efficiency, it was found that infections of the reproductive tract and ovarian dysfunctions nearly doubled the services required per conception and increased the calving interval approximately 150 days. Expressing cysts and corpora lutea by hand resulted in an increase in the rate of twins, abortions, and retained placenta. Cows having any unusual parturition should be given an adequate period for recovery before they are rebred, according to the findings of the scientists at the Washington station and other stations.

New York (Cornell) station considers that management and disease are equally to blame for reproductive troubles. The management faults include: Failure to recognize heat periods, breeding cows too soon after they freshen, and failure to maintain adequate records.

which results in bulls with poor breeding ability being kept too long. The disease most frequently encountered is vibriosis. It plagues the cattle industry throughout the Nation. Many brucellosis-free herds still suffer economic losses from reduced calf crops and lowered milk yields caused by *Vibrio fetus*.

Critical studies of the lesions produced by *Vibrio fetus* have been hindered by the tissue deterioration which usually precedes actual abortions, also by a lack of suitable laboratory animals. The Michigan station, using goats, has been able to describe lesions considered typical of *V. fetus* infection. These were produced by intrauterine inoculations of the organisms. The station also made observations on several animals inoculated intravenously and found that there was an apparent absence of the organisms in uterine material. Thus *V. fetus* may be capable of causing abortions in a manner yet unexplained. Inability to demonstrate its presence by bacteriological examination of the uterine material may turn out to be an important clue that, sooner or later, will lead to explanation of some of the presently undetermined causes of abortions.

The North Carolina and New York (Cornell) stations found that there are limitations to the blood agglutination test as a diagnostic tool. It serves best perhaps as a herd screening test. These stations and the Storrs (Connecticut) and Oregon stations report encouraging results with a new test (tampon) based on examination of cervical vaginal mucus for *Vibrio fetus* agglutinins. Preliminary results indicate that the new test is more sensitive than the blood test and will thus pick out additional infected animals missed by the latter.

Vibriosis is spread mainly, if not entirely, by infected bulls during service. The infection may also be spread by artificial insemination if the semen is not properly treated with antibiotics. The New York (Cornell) station treated contaminated semen with 500 units each of penicillin and streptomycin, diluted at least 1 to 25, and held for at least 6 hours before use in order to inactivate vibrios.

Infected heifers and cows eventually conceive although they may require many services and often have long estrual cycles. In an attempt to overcome this type of sterility due to *Vibrio fetus*, the Storrs (Connecticut) station employs intrauterine infusions with antibiotics. Following such treatment 34 of 41 repeat breeding cows conceived from their first service. The station also found that bacterins prepared with dead *V. fetus* cells are not very satisfactory for immunization purposes. The North Carolina station, on the other hand, reported encouraging results with living *V. fetus* attenuated by chick embryo passage. These findings warrant further study of the vaccine for use as a means of controlling vibriosis.

Another disease that occurs in a large percentage of dairy and beef cattle herds is nodular vulvitis, more commonly known as granular vaginitis. The cause of this disease is not clearly understood. The Rhode Island station has isolated *Escherichia coli* from a white, pustular lesion on the vaginal wall of a cow. Lesions of this type are sometimes seen in cases of granular vaginitis. After a series of transfers on laboratory media the organism was used to inoculate an apparently disease-free heifer 6 months of age. After 6 days, typical lesions of granular vaginitis developed and persisted. Repetition of previous experiments at this station on the value of antibiotics fed

in the hope of controlling granular vaginitis, gave disappointing results. The severity of the disease was just as great in the medicated animals as in the controls. So far, attempts by the West Virginia station to isolate a virus agent in connection with this disease have not been successful. Scientists at the Michigan station recovered an organism from an acute case of granular vaginitis which, when injected into susceptible virgin heifers, produces typical lesions 2 to 4 weeks later. Infertility is more likely to be encountered in animals in acute stages of this disease, according to preliminary observations.

Management, nutrition, and inheritance as factors involved in reproductive disorders are also being studied. The Nebraska station observed difficulty in raising the production of its breeding herd to the level desired because numerous high producers had to be culled. Thirty percent of the cows in the herd were needed for replacements, whereas only 36.4 percent of all calves born were heifers. This would indicate that under the conditions existing in that herd only about 1 heifer calf in 15 could be sold as surplus or culled. It was also observed that cows on an intake of 50 micrograms of carotene per kilogram of body weight exhibited irregular and delayed estrus and had difficulty producing normal calves after finally conceiving. In other words, the more the time and the generations during which animals are maintained on minimum carotene requirements were lengthened, the greater were the difficulties experienced in securing normal growth and reproduction. These findings have been confirmed by station studies in Idaho, Oregon, Washington, and West Virginia.

Tennessee station scientists encountered no greater breeding difficulties with heifers in high condition than with those that were not fat. Even bulls showed no changes in fertility characteristics that could be attributed to feed. The New York (Cornell) station found that heifers which are underfed require about 5 months longer to become sexually mature than do well-fed heifers.

Bulls kept on a low level of nutrition at the Minnesota station produced as good quality semen as those maintained on a high level, but volume of semen was less. Bulls underfed since calfhood (a balanced diet but low in energy) by the Pennsylvania station did not gain physical or sexual maturity as quickly as do well-fed bulls. Blood constituents of the underfed bulls appeared normal, but the concentration and motility of their spermatozoa were reduced.

The New Jersey station observed no significant differences between cow families or between progeny of different bulls in breeding efficiency, indicating that heredity has little influence upon overall breeding efficiency. The New York (Cornell) station did find a difference in the breeding efficiency of dams and daughters.

The Rhode Island station found no beneficial effect on conception rate, hemoglobin levels, or on granular vaginitis in young heifers as a result of adding a complete mineral mixture to the ration. This agrees with findings at the New York (Cornell) station, which showed that specific deficiencies of vitamins or minerals, with the possible exception of cobalt, were generally not important factors in the sterility problem. The Washington station continues to find that the cows in its experiments which have been fed bonemeal, irradiated yeast (vitamin D), or a combination of the two, breed less regularly than those on a standard ration recommended for dairy cattle in that State. The differences are not significant.

A high fertilization rate among so-called infertile heifers, is believed to be caused by a subsequent high embryonic death rate (54.1 percent) during the first month of pregnancy, according to the Pennsylvania station. Genital abnormalities occurred in only 13.5 percent of the heifers studied and did not appear to be a significant cause of breeding failures.

Comparative studies at the Mississippi station on the genital organs or normal and difficult breeding dairy cows revealed that the latter had larger ovaries by weight and more acid cervical and vaginal mucus than did the former. Of the difficult breeding animals, 63.5 percent had infections in various parts of the genital system and 28.8 percent had obstructions that would mechanically interfere with spermatozoa and ova transport in the female tract. The uterine mucosa and cotyledons were so seriously eroded in 25 percent of the difficult breeding animals that normal fetal attachment could not occur. This suggests that impaired fertility may have been due to failure of attachment of the embryo rather than failure of fertilization.

Stilbestrol has frequently been recommended and used as a treatment for shy breeders. However, the Tennessee station was unable to determine ovulation in 21 cows treated with stilbestrol and examined post morten 24 hours later. The South Dakota station reported easier labor for cows at time of parturition when the hormone relaxin was injected just prior to calving. At the Illinois station cows were bred in a normal manner and then were separated into three groups. One group received injections of epinephrine and another oxytocin in an effort to speed the transport of spermatozoa to the site of fertilization. The third group was untreated. The conception rate in each of the two groups injected with hormones was significantly higher than that of the untreated group.

The Wisconsin station observed that the uterus is much more resistant to infection by bacteria near the period of estrus, when the estrogenic hormone is predominant in the endocrine fluids of the body. This apparently is a protective device to prevent bacterial invasion of the reproductive tract prior to breeding.

Vitamin A deficiencies

Studies at the Oklahoma station indicate that vitamin A deficiency is most likely to occur in beef calves during the first few weeks after birth if their dams have been on low vitamin A ration for some time. Unthriftiness, diarrhea, blindness, and secondary infection were common among the calves. A biopsy technique, developed at the Oklahoma station, was used to determine the liver stores of vitamin A and carotene in cows and calves. These were compared with the blood and milk levels and with health of animals. Pregnant cows on low carotene rations were able to maintain themselves for long periods on their liver stores, but their calves soon showed serious lack of vitamin A unless the cows were provided a ration adequate in carotene immediately after calving. These findings should aid in avoiding losses caused by inadequate nutrition under conditions where cows are wintered on dry grass low in carotene (provitamin A) and calve in the spring, especially following drought.

At the Colorado station it has been found that the native range grasses in the eastern dryland area of the State supply enough carotene

to meet the vitamin A needs of cattle during about 8 months of the year. Sorghum fodder, an important winter roughage in this area, was also low in carotene compared with good quality prairie or legume hay. The addition of 2 pounds of good quality alfalfa hay daily to a ration of sorghum fodder and soybean meal, fed to pregnant cows during the wintering period, resulted in a shorter breeding period. The cows weaned a higher percentage of calves at heavier weights than cows on an unsupplemented ration. In these studies alfalfa gave better results than fish-liver oil of equivalent vitamin A potency, as measured by blood carotene and vitamin A levels, weight gains, and general appearance of the cows. A supplement of dehydrated alfalfa meal also improved performance of calves on either a high or low protein supplement, resulting in higher winter gains and increased weight as yearlings.

Mineral deficiencies

In some of the very fertile peat and muck soils forage may contain from 5 to 150 parts per million of molybdenum. Even with abundant feed, cattle on muck pastures scour, lose weight, develop an anemia, and die unless remedial measures are taken. Research at the Florida station has shown that application of copper fertilizers alone will not rectify the difficulty, because of the inability of the plants to take up sufficient copper to counteract the effects of molybdenum. Excellent beef production records have been attained when, in addition to the application of copper fertilizers, mineral mixtures high in copper have been made available to the cattle. Drenching with a solution of copper sulfate has been successfully used as a therapeutic measure.

Preliminary results in experiments currently being conducted by the Oklahoma station suggest that a high intake of manganese may reduce the ability of beef cattle to assimilate phosphorus from their ration, as indicated by blood phosphorus levels and weight of cows. In previous studies phosphorus supplementation resulted in satisfactory weight gains of heifers but failed to entirely correct the low percentage of calf crop and low weaning weight of calves.

Anaplasmosis

Anaplasmosis is a serious infectious and transmissible disease of cattle commonly found in the southern portion of the United States and occurs sporadically, though not infrequently, in other parts of the country. Originally the disease was considered to be a part of the tick fever (piroplasmosis) complex, but since 1910 it has been known as a specific disease entity caused by a minute parasite which invades the red blood cells and destroys a large number of them, so that the blood becomes pale and watery. Formerly it was thought to be transmitted, like tick fever, exclusively by the cattle fever tick, *Boophilus annulatus*.

Even after it was known to be a specific disease, separate and distinct from tick fever, it was thought that eradication of the fever tick would eliminate both tick fever and anaplasmosis. Unfortunately this expectation was not realized. Tick fever disappeared with eradication of the fever tick, but anaplamosis remained and spread into areas never included in the original tick quarantine area. It

has now been reported in 28 of the 48 States in the Union. Today anaplamosis is widely recognized as a disease causing heavy death and related serious losses resulting from decreased production of milk and meat.

In spite of the fact that extensive research has been carried on with respect to anaplasmosis in different parts of the United States and in other parts of the world, there is at present insufficient information to cope with the disease adequately and practically. (Report on the Agricultural Experiment Stations, 1949, pp. 20–22.) Additional information is needed on the method or methods by which anaplasmosis is transmitted under natural conditions. It has been shown experimentally that the disease can be transmitted by many kinds of ticks and flies, but their specific role in the spread of the disease under field conditions needs further investigation. Not all potential vectors that can transmit the disease under controlled laboratory conditions are necessarily the vectors of the disease under field conditions. When, however, vectors that do actually transmit the disease under natural conditions are fully determined it becomes possible to seek methods for their control.

Adequate medicinal treatment for the disease is being sought. Thus far, no drug has proved to be completely satisfactory and even those drugs that appear to have some value in aiding the affected animal to withstand and recover from an attack of the disease, do not destroy its cause. Such animals remain carriers of the infection just as do those that recover from an attack without drug treatment. Recovered animals serve as reservoirs of infection and constitute a potential source of disease to susceptible animals. Last year the Florida station reported on the value of blood transfusions as a clinical treatment for the disease. The Texas station is making additional tests along these lines.

The Louisiana, Kansas, and Oklahoma stations have reported results obtained in experiments where aureomycin and termmamycin were used for treatment. In Louisiana these antibiotics showed promise as inhibitors of the agent that causes anaplasmosis, if treatment is started early and is adequately supported by good nursing care of the animals. Mortality was greatly reduced by the measures mentioned, pointing to the possibility that ridding carriers of their infection through use of the antibiotics may prove practical in controlling outbreaks and eliminating spread of the disease.

The present geographical distribution of anaplasmosis in the United States indicates that carrier animals have been responsible for the spread of the disease from infected to noninfected areas. Current movements of cattle from one section of the country to other sections make it imperative that practical means be sought to detect such carriers and thus eliminate them from trade channels. The complement-fixation test, modified for this purpose, has been used as a means for identifying carrier animals by the Department and several State experiment stations. The success of the test depends largely upon a suitable antigen, or test fluid, which is used with the animal's blood serum to determine anaplasmosis-free or anaplasmosis-infected cattle. During the past year the Maryland station has made an effort to produce a more effective antigen. Cooperative experiments with the Louisiana and Oklahoma stations are now under way to test the efficacy of the newly developed material.

Research on anaplasmosis is necessarily an expensive and long-time procedure, mainly because cattle must be used as experimental animals, since small laboratory animals have not proven susceptible to the disease. Thus, one way of reducing expense of this type of study would be to find a small laboratory animal in which anaplasma could be propagated. The Florida station has tried the cotton rat and pocket gopher—so far with no success, but the search is being continued.

In summary, additional information needed to solve the anaplasmosis problems includes: (1) The nature of the causative agent, (2) the modes of its transmission in the field, (3) treatment of clinical cases and carrier animals, (4) accurate means of detecting carrier animals, and (5) biologic methods for controlling the disease.

"X-disease" (hyperkeratosis of cattle)

A review of the study of X-disease in cattle reveals that excellent progress has been made toward solving a major disease problem through collaborative effort.

The 1948 Report on the Agricultural Experiment Stations (p. 116) stated that "Formal research memoranda are being drawn up by several of the State experiment stations for the purpose of studying the disease under local conditions and a number of them, with the Department, have initiated cooperative action to trace down the factors responsible for this serious malady and to develop the means for combating it." At the time that report was made there was a veil of mystery surrounding the disease that had been responsible for heavy losses in affected herds over a large part of the Nation. The following State experiment stations joined with the Department of Agriculture and cooperators from industry in research on X-disease: Alabama, Colorado, Storrs (Connecticut), Georgia, Illinois, Indiana, Kansas, Michigan, Montana, Nebraska, New Jersey, New York (Cornell), North Dakota, Pennsylvania, Tennessee, Texas, and Virginia.

In the 1951 and 1952 reports it was possible to summarize some of the findings, that have now been substantiated further. Highly chlorinated napthalenes contained in certain lubricants were shown to be the cause of X-disease. The findings made it possible for lubricant manufacturers and other branches of indutry to eliminate the toxic substance in materials used for operations involving cattle or in the processing of feeds for their use. In addition, preventive measures were encouraged to keep cattle away from farm machinery, crankcase oil, or oil drums and similar containers, where they might eat grease or oil containing the compound.

Calf scours

This is an acute, contagious, infectious disease of young or newborn calves, characterized by a profuse diarrhea and rapid exhaustion. In a majority of cases the calves affected are very young, but in severe outbreaks the infection may be spread to older calves. The Pennsylvania station, which previously reported (1951 Annual Report, p. 85) that the administration of low levels of drugs and antibiotics at the time of birth reduces the incidence of scours, has verified its preliminary findings. This preventive method for handling calf scours may be effective in avoiding the severe outbreaks that often occur when

several young calves in a herd develop acute cases of the disease. Those calves which later develop diarrhea respond to treatment in a large percentage of cases. Excellent results were obtained at the Colorado station on over 600 scours-sick calves, following treatment with a form of sulfathiazole.

Milk fever

Each year dairymen experience considerable financial loss as a result of cows developing milk fever. This is a common and widespread condition, characterized by paralysis and a rapid lowering of the blood calcium, that usually affects high producing dairy cows. Prompt veterinary treatment saves many cows from death; however, a simple means of preventing its occurrence is highly desirable. The Washington station studied mineral balances and blood levels of cows at time of parturition to see if differences in mineral metabolism might exist between cows which do and those which do not come down with parturient paresis. These scientists discovered that a negative calcium and potassium balance exists in cows developing milk fever, even before parturition. Such cows, although consuming the same amount of calcium prepartum as did others, also excrete more calcium. Thus they are severely deficient at parturition, and this calcium deficiency probably brings on the attack of milk fever.

Although there is no definite answer to why this prepartum deficiency occurs, research has provided another possible preventive of milk fever.

The Ohio station has evidence that large amounts of vitamin D (30 million units per day) fed from 5 to 7 days before calving will prevent milk fever. Feeding such large amounts of this vitamin is not harmful to the cow if the feeding is limited to a few days before calving. Plans are being made to make the vitamin D available in suitable form, and to formulate definite recommendations for milk fever prevention.

Calf pneumonia

Chronic calf pneumonia is characterized by a cough, listlessness, and pus discharge from the nostrils. Post mortem examination of animals with this disease reveals numerous small or a few large abscesses in the lungs. Antibiotics and sulfa drugs will not alleviate the condition once the infection has become established in the lungs. The causative bacteria isolated at the South Carolina station and made into a killed bacterin has been very effective in controlling the disease. Injection of the bacterin into calves at birth, and at 1 week, 1 month, and 3 months of age resulted in practically 100-percent control. The station has additional studies under way to develop measures for obtaining complete cures.

Mastitis

In spite of the great number of investigations that have been carried on and the recommendations that have resulted for treatment and control of mastitis, it continues to be one of the greatest problems encountered by the dairy industry. In addition to various organisms, many factors, such as management, heredity, and nutrition, make a

solution more difficult. As one organism is studied and methods for its treatment or control are made available, another organism equally bad arises to take its place. At first *Streptococcus agalactiae* was thought to be the causative organism, but a number of other organisms have now been shown to be involved.

Particular attention has been given by the New Hampshire station to the diagnosis and control of staphylococci, reported by a number of the stations as an important cause of both acute and chronic mastitis. In some herds staphylococci produce a greater incidence of infection than *Streptococcus agalactiae* and often become of special concern in herds in which streptococcal mastitis has been eliminated. This is in agreement with research results at the California station where it was also found that there is a relationship between mammary infection by staphylococci and the increase in age of the animal. The Virginia station points out that the characteristics of these staphylococci are similar to those found in human infections and food-poisoning, indicating the potential danger of the organisms from that standpoint. In one of the New Hampshire herds under study for 5 years, about 20 percent of the clean negative udder quarters became infected with staphylococci during each year. Detailed studies were made at that station on the characteristics of the organism and methods for its diagnosis were developed. The station found that staphylococci which cause either acute or chronic mastitis produce both alpha and beta toxins. It was demonstrated that the alpha-type toxin is particularly irritating to the mammary tissue and will produce typical cases of acute mastitis when injected into the udder via the teat canal.

Many findings are reported by the stations on experiments with drugs and antibiotics for control of mastitis. Of special interest is that reported by the Michigan station. Scientists there conducted research on radioactive penicillin infused into the normal udder of a cow. This has shown the pattern of distribution and whereabouts of the antibiotic under normal conditions. The results are being compared with those of a similar study conducted on an affected udder.

The Ohio station observed that resistance of milk samples to the action of *Streptococcus agalactiae* offers a possible means for estimating the relative resistance of cows to udder infection. The method utilized in Ohio's recent studies is based on the determination of the acid produced by the organisms when inoculated into milk samples. A marked loss in resistance is shown by milk samples from cows at the beginning of the grazing season. This suggests a possible explanation for some of the extensive herd problems at times encountered during the early part of the pasture season. Present and previous studies also indicate that the feeding of better quality roughages increases milk production and tends to support resistance levels, except when marked changes in roughage are made.

Open sheds reduce calf death losses

Although disease organisms are the primary causes of calf diseases and mortality, a number of predisposing factors are sources of infection. One of these is improper housing. The Missouri station reports that calves raised in open-type structures suffered a 3.7 percent lower death rate from the scours-pneumonia complex than calves raised in closed buildings. Washington station calves raised in both

open and closed sheds under the cool and damp Northwestern climate survived best in open-type buildings. Four times as many calves died in the closed-barn group than in the open-shed type of building.

Electronic device removes tramp iron from feed

Losses of valuable farm animals from "hardware sickness" emphasize the importance of removing tramp metals from feedstuffs. Borrowing the idea from a device used in the lumber industry, engineers of the California station developed an electronic detector-rejector that promises to be effective in spotting and removing pieces of tramp iron, such as nails, wire, and other fragments, from chopped grain or hay. The device, placed on the blower pipe, detects the metal pieces while the cut feed is being blown through the pipe. The detector is synchronized with a rejection gate placed a little further along the blower pipe. The gate is so timed as to throw the contaminating metal out of the feedstuff just before the latter is blown into the hopper or bin.

Poultry Diseases

A number of the diseases that formerly plagued the poultryman are now being successfully combatted. Roup, aspergillosis, tuberculosis, pox, pullorum, and coccidiosis, are no longer considered major problems. Rickets, perosis, gout, and other nutritional disorders also cause little concern. Nevertheless, losses appear to mount and new diseases are being recognized. One disease complex alone, lymphomatosis or leucosis, has been credited with causing nearly one-half of all mortality among adult chickens and an undetermined loss among young chickens. Deaths from respiratory infections, such as infectious bronchitis, Newcastle disease, and air-sac infection (chronic respiratory disease), are heavy.

Leucosis or lymphomatosis (breeding for resistance)

Experiment stations of 10 States—Alabama, California, Illinois, Iowa, Michigan, New York (Cornell), North Carolina, North Dakota, Pennsylvania, and West Virginia—in addition to the Regional Poultry Laboratory of the Department, East Lansing, Mich., have endeavored to control leucosis through breeding. In 1943 the California station presented results of its 8-year-study of progeny-test selection in the development of relatively resistant and suspectible lines of chickens. Despite continued selection for resistance, the disease was almost as great in the production line as it was in the foundation stock. Nevertheless, this station believed that progeny-test selection provided a method of keeping incidence of the disease within reasonably low limits and should be practiced "until some other more effective means of control may be found."

Seven years later, the New York (Cornell) station reported that during 13 years of research the difference in mortality from neoplasma (mostly leucosis) among proved sires of susceptible and resistant strains constantly increased. These differences were very significant and indicated the effectiveness of the genetic selection practiced. In 1953 the same station showed the feasibility of breeding strains of White Leghorns capable of high egg production and so resistant that,

when exposed to severe leucosis, their mortality from that disease was almost negligible. The North Carolina station, in its recent studies on White Leghorns, found that mortality from leucosis has been higher in some of the hybrid combinations than in the purebreds, even though apparent gains have been made by the hybrids in other characters affecting egg production.

Breeding experiments at the Iowa station have progressed to the point where selection for leucosis-tumor resistance and susceptibility in three generations of birds has been accomplished. The resistant birds of the third generation, when tested with a virulent tumor, were more resistant than either a random group of chicks or those from the selected susceptible line.

Newcastle and allied respiratory diseases

Previous annual reports have reviewed the history and progress of research on Newcastle and similar respiratory diseases. Numerous station studies are in progress on immunization and other control measures, designed to discover control measures for new "strains" of the virus as these may appear, and also on the improvement of diagnostic methods. The Wisconsin station has continued its collection of American strains of Newcastle disease virus and its program of typing the strains has been augmented. In addition, its laboratory supplies other experiment stations with standard immune sera and stock virus for use in their studies. According to the Wisconsin scientists, Newcastle disease, like the common cold, can spread through the air and infection can spread before symptoms appear. Infected chickens can spread the virus in the air one or two days before disease symptoms appear.

The Michigan station, interested in the possibility of contamination from virus vaccines, has found that the virus of avian visceral-lymphomatosis may be present in certain chicken embryos. When these embryos are used for production of vaccines, the virus may be transmitted to vaccinated chickens. Knowledge of this makes possible the establishment of necessary safeguard procedures in vaccine production.

The Storrs station (Connecticut), in studying possible host range of the virus, found that 6 calves and 1 hog inoculated intracerebrally with egg-propagated Newcastle disease virus showed minute brain lesions on post-mortem examination. The relationship of Newcastle disease virus and poliomyelitis virus has been studied for several years by the Maryland station. Scientists at this station found that the Minnesota strain of Newcastle virus will protect monkeys against one of the three strains of poliomyelitis virus. Whether the evidence of protection was due to immune bodies or to blocking action has not been determined. The common English sparrow has been found by the Indiana station to be a potential carrier of Newcastle virus.

The Massachusetts station has demonstrated that vaccine prepared from a slightly virulent strain can be administered to poultry 3 to 20 weeks of age by spraying the vaccine over the heads of the birds in an enclosed house or range shelter. This method may be used as the initial vaccination of the flock or for revaccination. Respiratory symptoms may be quite pronounced but paralytic symptoms are

absent. Mortality as a rule is negligible but may reach 1 or 2 percent in the younger flocks.

Field tests indicate that this method of vaccination provides satisfactory protection. Nebulization (spraying) of B_1 vaccine (Blacksburg strain) has been found by a number of stations to be satisfactory as a method of vaccination against Newcastle disease. The immunity thus produced was as good as when the vaccine was dropped into the eye or nostril. By this method, the Virginia station has found that 100 day-old chicks can be easily vaccinated every 3 minutes by one individual and only about one-half as much vaccine is required.

Reports of breaks and the isolation of virulent Newcastle disease virus following vaccination by the intranasal route with B_1 vaccine suggested to the Texas station that there is need of further exposure to the B_1 virus at a time when parental immunity would not interfere. The difficulty of catching the chicks when they are 4 to 5 weeks of age prompted the use of the virus in the drinking water. One group which received the vaccine in the drinking water at 44 and 50 days of age showed 100-percent protection when challenged.

The New Hampshire station has shown that a combination of its low-virulence strain of infectious bronchitis with B_1 Newcastle virus into a single vaccine is effective for immunizing chicks against both diseases. These findings and those of the Virginia station are in agreement. However, the duration of resistance is still unknown. The Virginia station, by tagging the virus in the vaccine with radioactive isotopes, has been able to determine its location in the bird's body after nebulization. Such tagged virus was detected in the trachea, lungs, and air sacs of the birds.

Breeding for resistance to Newcastle disease has been carried out by the Delaware and Oklahoma stations. From six selected families of pedigreed New Hampshires at the Delaware station, matings were made between those showing high and low resistance in the first generation for production of the second generation. These were challenged with the California strain of Newcastle disease virus. Using daily mortality as a criterion for measurements of differences, a significant difference was observed between the males used in one of the crosses. The differences observed indicate that there may be an inherent mechanism that causes some families to die faster than others when challenged with Newcastle disease virus.

As a part of a study on the physiology of avian reproduction, selection has been made by the Maryland station to produce two strains of chickens differing in their response to thiouracil. A significant result thus far is a marked difference between the two lines in their resistance to Newcastle disease. This is additional evidence that Newcastle disease may be partially controlled through breeding.

Infectious bronchitis

The serious consequences of infectious bronchitis outbreaks in laying flocks have stimulated interest among poultrymen and veterinarians in immunization of replacement pullets. Some hens affected by the disease go out of production and come back slowly, and the interior and exterior quality of their eggs is impaired permanently. Other flocks may never come back into production, even though they look like good laying birds. The Rhode Island station has been carry-

ing on a program of flock vaccination using an egg-propagated virus which in turn is inoculated into "seed" birds that transmit the protective virus to the rest of the flock. The data on 3- to 6-week old groups indicate that exposure of birds in this way during the period mentioned is highly practicable.

At the New Hampshire station a concentrated effort has been made to select a vaccine strain for infectious bronchitis, and one has been found that is apparently safe and has promising immunizing properties under laboratory conditions. It has been found possible to combine this strain with the B_1 strain of Newcastle virus and immunize birds against both diseases, using a spray technique under laboratory conditions. Field trials of this technique are now under way. California station veterinarians are experimenting with a new program of 100-percent immunization against infectious bronchitis of approximately 100,000 chicks. All chicks in a flock are inoculated between 4 to 16 weeks (optimum age 6 weeks) while they are still under brooder heat and before vaccination for other diseases. Chicks get over the disease in 2 weeks and are thought to be immune for life. Search is being made for a vaccine that will produce immunity without any harmful effects on the birds.

The New York (Cornell) station is continuing its attempt to lessen virulence of the bronchitis virus by yolk-sac cultivation. Three experiments with adapted bronchitis virus of reduced virulence have been carried out without loss of the immunizing value of the virus. They also report that eggs from flocks recovered from bronchitis may be hatched without disease transmission to the chicks.

Chronic respiratory disease

Preliminary findings have grown out of the cooperative studies (stations and USDA) on chronic respiratory disease reported last year. These serve to clarify the thinking that exists regarding so-called "air-sac disease" in chickens. The causative agent is apparently a pleuropneumonia-like organism. The Massachusetts station, as well as others, has noted that onset of the disease is usually slow, and its course is protracted. In uncomplicated outbreaks, the respiratory symptoms and lesions occur in the upper and lower respiratory tract with striking involvement of the air-sacs. Growth of the bird is slowed and there are some deaths. When the disease it further complicated with *Escherichia coli*, Newcastle disease, or by infectious bronchitis, the outbreak becomes very severe and many birds die. Although frequently termed air-sac disease, the condition may actually be a combination of diseases.

Chronic respiratory disease is reproducible experimentally in chickens and other avian species. The agent can be propagated in embryos and produces characteristic lesions in the region of the joints and in the lower respiratory tract including the air-sacs. Carriers have been detected among survivors of an outbreak. The disease agent is penicillin-resistant but is more sensitive to some of the other common antibiotics, especially under laboratory conditions. In a recent report by the Storrs station (Connecticut), it was shown that terramycin in mineral oil, injected subcutaneously, helped in the treatment of this disease in two groups of pullets.

Better diagnostic techniques are needed. The Washington station

showed by a simple slide agglutination test that there are serum-antibodies in common for eight pleuropneumonia-like agents. With this standard method, an early diagnosis of the condition may be made, making it possible to institute specific treatment and thus save many birds.

Fowl cholera

Antibiotics and sulfonamides were tested at the South Dakota station for their effectiveness in controlling fowl cholera. When antibiotics were included in rations at growth-promoting levels, chicks were susceptible to fowl cholera on exposure with cultures of the causative organism. When given at therapeutic levels in the ration, terramycin afforded complete protection but penicillin and streptomycin did not significantly lower mortality. Under the same conditions, no losses occurred in groups of chicks which received sulfaquinoxaline and sulfamerazine in the ration.

General disease resistance

Diseases on which genetic information has been obtained are: Infectious coryza (*Hemophilus gallinarum*) by California, pullorum by Illinois, and fowl typhoid by Iowa. Many stations, however, are breeding for general disease resistance along with other desirable economic factors. The Alabama station's Auburn strain of White Leghorn (strain A) continues to show low adult mortality. Another Leghorn strain, known as strain D, is being selected for disease resistance. Crosses of strain D males and strain A females produced offspring that were superior to either of the parent strains in adult livability as well as in egg production and other traits.

At the Oregon station, selection on the basis of henhouse egg production to February 1, led to a significant decrease in mortality from all causes through five generations in the experimental flock. This decrease is marked, not only up to February 1, but also for the whole laying year. It indicates that livability on a family basis during the early part of the year bears close relation to livability during the whole laying year.

Lethal genes

Results of research at the Illinois, Indiana, Kansas, and New York (Cornell) stations have shown that death in chickens is sometimes caused by a specific lethal gene. In 1950 the Illinois station reported a sex-linked recessive gene called "Shaker" that is responsible for a peculiar nervous disorder manifested by rapid movements of the head and neck and a progressively increasing difficulty in walking without stumbling. At the same time, Indiana station's work revealed a similar nervous disorder designated "Jittery," so lethal that only about 1 percent of the females reached maturity. The Kansas station, through the mating of an early-feathering crossbred male, heterozygous (impure) for Shaker, to late-feathering Rhode Island Red and Black Australorp pullets has brought out some linkage relationships of the gene for this lethal condition. The apparent lack of linkage of the genes for barring and silver with that for Jittery, as found

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by the Indiana station, is probably caused by the great length of the sex chromosome. The definite linkage between Shaker and late-feathering supports evidence for the belief that separate genes at different loci produce the Jittery and Shaker traits. These accumulating facts make it possible for the pedigree poultry breeder to eliminate lethal genes from his breeding flock by progeny testing.

Nutrition and Disease Control

Practically all of the State experiment stations are engaged in phases of research dealing with the interrelation between poultry nutrition and health. A few typical examples follow.

Ascites in turkeys

Eight experiments have been conducted by the Pennsylvania station to learn more about the relation between nutrition and ascites (dropsy) in turkeys. The relative toxicity of seven salts fed singly or in combinations was tested. The sodium ion was found to be the agent responsible. It was more toxic in the form of chloride salt than in the form of either citrate or acetate salt.

Pullet disease

The Louisiana station undertook an experiment on the effects of two different levels of nutrient intake on the performance of laying hens. The flocks fed a low level of nutrient intake, approximately 75 percent of the allowance recommended by the National Research Council (NRC) for all nutrients except energy, had twice the number of deaths from "pullet disease" or "blue comb" as the flock receiving a high level of intake that contained 125 percent of the NRC recommended allowance.

Articular and cervical paralysis in geese

Goslings fed the standard chick-starting ration adopted by the Minnesota station frequently develop hock disorder when brooded either in batteries or on litter. Post-mortem examination revealed, in each case, that the tendon of the tibia had slipped out of the condyle, justifying the application of the term "perosis," to the condition. In research designed to determine the cause of this malady, 84.6 percent of all goslings fed the basal diet alone developed perosis in 3 weeks. The addition of 40 milligrams of niacin (nicotinic acid) per kilogram of diet completely prevented the perotic condition.

The Minnesota station also found that a deficiency of either choline or pteroylglutamic acid (folic acid) will cause goslings to develop an articular paralysis due chiefly to involvement of the hock joint. Goslings on a pteroylglutamic acid deficient diet, in addition to having weak legs, also manifested a weakness of the neck. This type of paralysis of the neck was cured by an intramuscular injection of crystalline pteroylglutamic acid.

Hock disorder in turkeys

The Washington station has found that supplementation of the diet of turkeys with 75 milligrams of niacin and 50 milligrams of vitamin

E per kilogram of feed was ineffective in alleviating hock disorder. The use of soybean oil meal, however, completely prevented enlarged hocks under conditions at the station. On the other hand, at the Minnesota station a high incidence of this condition occurred on a corn-soybean oil meal diet. Whole liver powder aggravated the condition, but dried brewer's yeast (5 percent), choline chloride (0.1 percent), and methionine (0.3 percent) helped prevent the trouble.

Bowed legs in ducks

Leg weakness, characterized by a severe bowing of the legs and ultimately by complete crippling, has been observed in Pekin ducklings raised on wire-mesh floors and fed practical rations at the New York (Cornell) station. A similar leg weakness is frequent in the Long Island area and represents an important economic problem since ducklings afflicted with the disorder usually do not make normal weight gains and therefore represent a loss at market time. The station showed that this disorder is due to a niacin deficiency and can be prevented by supplementing the diet with 5 to 7.5 percent of dried brewer's yeast or by adding 10 milligrams of synthetic niacin per pound of ration.

Riboflavin deficiency

The effect of riboflavin deficiency on the blood forming (hematopoietic) system of animals has been noted repeatedly. In 1943 the Wisconsin station, in studies on dogs, reported that an adequate riboflavin intake is necessary for normal hemoglobin formation. Until recently, however, no similar investigation has been carried out on the chick; and since riboflavin is important in the nutrition of this species, a study was made by the New Jersey station of the hematology of the chick suffering from this deficiency. It was observed that such a deficiency in White Leghorn cockerel chicks produced increased blood separation (hematocrit), decreased mean corpuscular volume, and decreased mean corpuscular hemoglobin concentration.

The most important change noted in the blood picture was the early appearance of a marked increase in certain colorless cells of the bloodstream (heterophilia leukocytosis). The increase in heterophil concentration appeared just before the occurrence of curled-toe paralysis, also in mild deficiencies where no paralysis was seen. The deficiency had no effect on the hemoglobin level, the erythrocyte count, or on leukocytes other than heterophils.

Rickets in chickens

The feeding of vitamin D and proper calcium-phosphorous levels in poultry rations for the prevention of rickets has been practiced for many years. However, the more rapid growth in chickens obtained today through our newer knowledge of genetics, nutrition, and management, requires higher levels of the vitamins, especially those intimately involved in growth, than were necessary even a decade ago. This fact is certainly true of vitamin D_3. Recent research at the Nebraska station indicates that more than 300 units of D_3 per pound of ration are needed by growing chicks during the first 8 weeks, undoubtedly because of the greatly accelerated growth of our modern

strains of market poultry. Although as much as 1,200 International Chick Units of D_3 per pound of ration did not harm the chicks in the Nebraska station's experiments, nevertheless, some tests have shown that excessive amounts of this vitamin have an unfavorable effect on growing chickens. It is concluded that slightly more than 300 International Chick Units of vitamin D_3 per pound of ration are required for normal calcification of the bones of broiler chicks.

Vitamin K deficiency

An experiment conducted by the Texas station has brought out the fact that hens used to produce eggs for commercial chick hatching should get ample dehydrated alfalfa as a source of vitamin K. From the early research carried on in this field by the California station, dehydrated meal was shown in 1935 to be a good source of vitamin K. But the studies also revealed that the amount of alfalfa in the diet of the hen could influence the occurrence of spontaneous hemorrhages in chicks fed a vitamin K deficient ration. In vitamin K deficiency there is a failure to form prothrombin in the blood-clotting cycle of the chick. The deficiency goes unnoticed in uninjured chicks, but if an open wound injury occurs to a vitamin K deficient chick, the blood will not clot and the chick will bleed to death.

The Texas experiment called attention primarily to the fact that hemorrhages may occur during the first week of the chick's life when the dams are not fed alfalfa or some other source of vitamin K. The number of chicks that die just after hatching is also decidedly increased by hemorrhaging of the navel cord. Hens from which the chicks for the Texas experiment were obtained had been fed a practical type of diet made up of corn and soybean oil meal plus added vitamin A, vitamin D, riboflavin, calcium pantothenate, niacin, choline, and vitamin B_{12}, along with sources of calcium, phosphorus, and manganese. From 35 to 40 percent of the chicks bled to death within 24 hours after wingbanding.

In another test in which fishmeal was added to the basal ration, a high percentage of chicks from hens not fed alfalfa hemorrhaged to death shortly after hatching, either from bleeding at the navel cord or from wingbanding when this operation was carried out.

Similar observations have been made at the Illinois, Kansas, West Virginia, and other stations in studies in which alfalfa was not a component of the breeder ration of laying hens. A source of vitamin K had to be added to the rations to prevent hemorrhaging of the newly hatched chicks.

Fur Animal Diseases

Distemper

Distemper is one of the serious problems facing the mink industry of this country. The U. S. Department of Agriculture's Fur Animal Disease Laboratory at Pullman has been working in cooperation with the Washington station in testing the effectiveness of live egg-adapted distemper virus as a vaccine. It was found that this type of vaccine provided protection more rapidly than could be expected from the older type killed-virus vaccines. Commercial vaccines of this live-virus type have only recently become available.

Yellow fat disease

In recent years it has been necessary for mink raisers to feed more fish to their animals because it is cheaper and more plentiful than the horsemeat that once was the bulk of the mink diet. The Fur Animal Disease Laboratory at Pullman, in cooperation with the Washington station, discovered that steatitis or "yellow fat" disease of mink was a result of this increase in fish in the mink ration.

The same disorder occurs in swine when they are fed large amounts of fish. The findings of this laboratory and station that adequate vitamin E added to the mink ration prevented yellow fat disease are important not only to the mink industry but also to the swine industry. Some pigs have been condemned at slaughter because of the yellow color of their fat following the feeding of fish.

This work has prevented recurrence of outbreaks of the disease similar to those that occurred in the mink industry during 1947 and 1948. At that time, ranchers lost thousands of dollars because of steatitis.

Diseases of Swine

Reducing losses in young pigs

Why is it that such a large percentage of pigs farrowed each year fail to reach market? The problem is far from simple and in recognition of its seriousness, 14 State agricultural experiment stations, the U. S. Department of Agriculture, and the Hormel Institute are working as a team in a regional program designed to find ways of reducing such losses. Some of the findings were reported in the 1950 Annual Report (p. 158). Major emphasis is now being placed on enteritis in young pigs, which at this time appears to be the number 1 problem. The study of enteritis is being approached from both the disease and nutritional viewpoints. After satisfactory information has been obtained on this phase, the cooperators will study the next most important disease or condition contributing to pig losses. Meanwhile, the States continue their own station studies covering other aspects not supported by allocated regional funds. These aspects are complemental to the regional study and often provide much valuable information, which is freely exchanged during the technical committee meetings.

Veterinarians at the Indiana station were the first to describe transmissible gastroenteritis (TGE) in pigs. As observed in sporadic outbreaks, the disease was characterized by diarrhea, vomiting in some cases, rapid loss of weight, and a high death rate in baby pigs. Although TGE has not assumed epidemic proportions, it is potentially one of the most serious diseases facing the swine industry because of its highly contagious and fatal character. It is apparently caused by a virus. Only swine are susceptible, and clearly defined symptoms and lesions occur only in young pigs. Hence, investigational work with this virus is handicapped by lack of a readily available, easily managed laboratory animal. Currently, an experiment is in progress at the Illinois station to establish the TGE virus in rabbits by serial inoculations. There is promising evidence that this has been accomplished, but it must be confirmed by further tests.

One of the difficulties encountered in studying the virus is that it could not be propagated by the usual methods. The Illinois station is

attempting to overcome this difficulty by growing virus in pig tissues. Since lung and liver tissues from pigs had not previously been grown outside the body, the first step was to find the proper nutrient conditions for them. Bits of lung tissue from 5- to 10-day-old pigs have now been grown in flasks, in a carefully buffered solution containing embryo extract and serum ultrafiltrate. Virus of known concentration is now being serially passed through such cultures at 5- to 7-day intervals. This material will then be inoculated into baby pigs to test survival or multiplication of the virus. If growth occurs an attempt will be made to produce a tissue culture vaccine. Recent studies at the Indiana station show that freezing and storage at low temperatures enabled the virus to remain active for 3 years. Attempts by this station to alter the course of TGE in pigs with several antibiotics and drugs were ineffective.

The Michigan station is seeking to establish the quantitative requirements of the young pigs for various vitamins and to obtain information on the pathology of vitamin deficiencies. Baby pigs fed a synthetic milk diet, deficient in riboflavin, gained only 0.01 pound daily, and developed a rough hair coat, scaly dermatitis, and diarrhea. A deficiency of pantothenic acid resulted in persistent diarrhea within 2 to 3 weeks and muscular incoordination within 3 to 5 weeks. The experiments indicate that the baby pig requires between 1 and 2 milligrams of pantothenic acid, and between 0.2 and 0.3 milligrams of riboflavin per 100 grams of dry matter in the diet.

Through controlled experiments, the Iowa station has established that weanling pigs require a minimum of 0.4 milligram of vitamin B_{12} per 100 pounds of feed for optimum growth. When fed a ration deficient in B_{12} the pigs became emaciated and unthrifty, but they recovered promptly when B_{12} was injected intraperitoneally, or fed in the ration.

Modern methods used in the extraction of fat and oils from commercial feeds commonly used for swine have resulted in rations of lower fat content than formerly used. This has stimulated research to learn more about the dietary fat requirements of swine. Pigs fed a fat-free ration by the Indiana station developed a scaly dermatitis, dull hair coat, necrotic areas, and unthrifty appearance within 40 to 60 days. Growth rate and feed efficiency were markedly reduced, and sexual maturity was delayed in comparison with littermates that received a ration containing 5-percent fat.

The problem of reducing baby pig losses and improving litter size and performance is also being studied through research designed to improve nutrition of the sow during gestation and lactation. Gilts fed aureomycin at the rate of 20 grams in a ton of their gestation ration, by the Indiana station, farrowed more and heavier pigs than those receiving only the well-balanced basal ration. The death rate of pigs during the first three critical days was about 7 percent more, however, than in the control lot. Continuing the aureomycin in the rations of gilts and their litters through the lactation period resulted in slightly heavier and stronger pigs at weaning. At the Michigan station supplementation of a well-balanced gestation ration with only 9 milligrams of aureomycin per pound of feed resulted in a small increase in litter size and birth weights and in number of live pigs.

The West Virginia station has been evaluating certain fish and animal byproducts as sources of unrecognized nutritional factors that

may be required by the sow for optimum reproductive performance. Adding condensed fish solubles and liver residue to the basal gestation ration at a 3-percent level resulted in stronger, healthier pigs, a 14-percent lower mortality, and the weaning of larger, heavier litters. The pigs farrowed by sows receiving the supplement were more thrifty in appearance and suffered less from digestive upsets. If it is substantiated by later results, this information should be valuable in improving the reproductive efficiency of brood sows.

Sows fed a practical farm ration supplemented with B-complex vitamins or an antibiotic, by the Missouri station, weaned more but lighter pigs than sows on the basal ration alone. Replacement of the soybean oil meal with tankage and linseed meal resulted in the production of smaller litters and the weaning of a higher percentage of pigs at heavier weights.

A study by the Missouri station (coop. USDA)[2] of factors influencing litter size in inbred and noninbred strains and crosses revealed that total intrauterine mortality amounted to about 46 percent. Only 65 percent of the ova shed by gilts were represented by normal embryos at 25 days after breeding. Of the 35 percent of ova that were lost, 5 percent were accounted for by nonfertilization and 30 percent by nondevelopment or early death of the fertilized eggs. Estimated embryo mortality between 25th day of gestation and parturition amounted to 1.38 pigs per gilt, or less than one-third as much as occurred before the 25th day.

Crossline gilts produced more ova than inbred gilts, which resulted in 1.85 more pigs per litter at the 25th day of gestation. Sows of increased age or body weight at time of conception shed more ova and had a lower litter mortality. Gross abnormalities of the reproductive tract were found in only 7 percent of the females examined. Further research is needed to determine the causes of this high incidence of early mortality, and the means of preventing it.

Vesicular exanthema

In 1932 word went out that what appeared to be the dreaded foot-and-mouth disease in swine had been found in Orange County, Calif. Clinically it was indistinguishable from natural and experimental foot-and-mouth disease or from experimental vesicular stomatitis of swine. However, by use of test animals it was established in 1934 that this was neither of the two mentioned diseases and it was designated vesicular exanthema.

This is an unpredictable disease as may be gathered from the fact that it was apparently confined to California for 20 years and then suddenly, in June 1952, made its appearance in garbage-fed hogs in Wyoming and by December 1 had been found in 32 States.

Affected swine exhibit vesicles (blisters) of varying size on the snouts, noses, lips, gums, tongues, on the feet, between the digits, around the coronary bands, on the balls of the feet, or on the dewclaws. Lesions on the udders and especially the teats have been observed in nursing sows. Lameness, as a result of foot lesions, appears in varying degrees. However, general systemic disturbances are not usually so severe as those seen in foot-and-mouth disease.

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[2] Hereafter, where the United States Department of Agriculture has given assistance in a specific field, that cooperation is indicated by the notation "(coop. USDA)."

Since spread of the disease—this is also true of several others of a serious nature—is primarily tied in with the practice of feeding raw garbage to hogs, recommendations for curbing or controlling this practice have been made and are receiving favorable attention in most States. Meanwhile, the California station, in cooperation with the Department and with veterinarians of the California State Department of Agriculture, is conducting studies on the problem. A new complement fixation test developed in the past year by the California station is providing ready identification of all available types of vesicular exanthema virus. This makes it possible to identify the disease without resorting to animal inoculations, a time-consuming and costly process, since swine are the only known readily susceptible animals. The test is performed with vesicular material collected from hogs in the field, and the results can be obtained within 24 hours.

Meanwhile, the station is not overlooking the possibility of finding a small animal that might prove to be a suitable host for the virus. They have found that dogs exposed by tongue (intradermal lingual) injections of the virus were irregularly susceptible to A, B, and F types. Four immunologically distinct types of the virus have been reported previously in California, but only three types A, B, and F, have been isolated recently. Samples originating in the Midwest without exception were found to be due to type B virus. This station has shown that hogs which have been infected with one type of vesicular exanthema virus can later be infected with another type. Promise of a successful adaptation of the test for specific identification of vesicular exanthema will provide a less time-consuming and less expensive method of differentiating between it and foot-and-mouth disease. This is an important contribution when one considers the ever-present threat of possible outbreaks of the latter disease and the fact that it must always be considered as a possibility when vesicular exanthema appears.

Diseases of Sheep

Listeriosis of sheep

During the 20 years that have elapsed since *Listeria monocytogenes* was shown to be the cause of circling disease or listeriosis in sheep, this disease has become of increasing economic importance. Losses from the nervous form of the disease or from abortions may at times be very high. Listeriosis appears to be spread from flock to flock through the transfer of carrier sheep that apparently show no symptoms of the disease. Limited experiments conducted at the North Dakota station show that bacterins prepared from killed listeria organisms will protect sheep against the disease under farm conditions.

The Nebraska station reports that three types of infection with listeria can be distinguished in experimental and natural listeriosis of sheep. In one type the infection is confined to the brain, in the second both brain and visceral organs are involved, and in the third type the infection exists in visceral organs only. The station also reports that considerable evidence has accumulated to associate the feeding of silage with outbreaks of natural listeriosis. Although this relationship has not been conclusively demonstrated, many lamb feeders exclude silage from their rations because of the risk involved in feeding it.

The natural reservoir of *Listeria monocytogenes* has never been determined. This has retarded the study of the disease in both animals and man. There is increasing evidence that the micro-organism is widely distributed in nature, perhaps in the form of a soil bacterium or as a saprophyte, and that only under specific conditions does it occur as a pathogen. It was felt at the Michigan station that failure to isolate this organism from sources other than the animal body, reflected a failure to recognize it in its nonpathogenic form. A study of the dissociation pattern of *L. monocytogenes* is in progress in an effort to identify the various colonial forms in which this bacterium might occur. So far nine colonial forms have been identified, some rough and others smooth. Only the smooth form is highly pathogenic for laboratory rabbits when inoculated intravenously.

Biochemically, the rough forms are very similar to the smooth, and several of those tested produced high-agglutinating antibody titers against the smooth form when inoculated intravenously into rabbits; however, on subsequent challenge they afforded no protection. Additional investigations are in progress at this and other stations to provide needed information on effective methods of diagnosis, mode of transmission, methods of treatment, and a system of control for this disease.

Bluetongue in California sheep

In September 1952 a disease of sheep which causes severe mouth lesions, weight loss, and costly decline in wool quality made its appearance in California flocks. Affected sheep exhibited symptoms almost identical to those observed in flocks of Texas and Utah where it is known as sore-muzzle. As a result of studies of this disease, a virus has been isolated and identified as that causing bluetongue, a disease known in South Africa since the turn of the century, where it has been a cause of serious economic loss. California station veterinarians are now attempting to reduce the virulence of the virus by passing it through eggs and thus making it possible to produce a modified live virus vaccine similar to the one being used with great success in South Africa. In the continuing experiment, virus will be imported from sore-muzzle sheep of Texas and Utah to determine whether all the disease strains in the United States are the same. If the strains differ, all will be incorporated in the vaccine. Entomologists of this station are searching for the vector, or vectors, of the bluetongue virus, which in South Africa has been shown to be a gnat.

External Parasites

External parasites of domestic animals exact a continuing toll from livestock. Flies have been accepted in the past as a natural nuisance on and around livestock and a few lice or ticks often go unnoticed, but the annual loss from total tick, mite, or insect depredations is heavy. When external parasites carry disease or occur in such numbers as to cause epidemics, known controls are applied if they are practical under local conditions. Such measures are based on research aimed to protect farmers from reduced production through the lowered efficiency of their animals. The following are examples of successful external parasite control measures growing out of station research.

Hornfly control at lower cost

The Oklahoma station (coop. USDA) last year reported a 7-year experiment that showed that there was an increase of about 18 pounds in weight per beef animal in herds sprayed monthly during hornfly season with a 0.5-percent DDT. Since then the Oklahoma station has demonstrated that "rubbing posts" treated with insecticide solutions were as effective as monthly sprayings with 0.5-percent DDT at half the insecticide costs. There was practically no labor charge. The type of post made little difference, but location was all important. Best results were obtained when the posts were located where the cattle spent most of their time. A comparison of hornfly control in open and wooded pastures revealed that half the concentration of insecticide used in wooded pastures was effective in open pastures.

Clipping cows controls lice

That lice on milk cows can be controlled by clipping is indicated in Wisconsin station experiments. One group of cows was clipped, the other remained unclipped. The following winter, the groups were reversed. Each year, milk production was slightly higher in the clipped group. These tests are being continued to verify the findings. The station also ran clipping trials on heifers. Unclipped heifers were badly infested with lice by early February, whereas heifers clipped in the fall did not become badly infested until late March. The heifers that were clipped or reclipped in February remained louse-free for the rest of the season. One clipping in late fall and the other in late winter apparently controlled chewing lice. A single clipping was not sufficient since some lice lived through the clipping in protected areas, and their offspring reinfested the animal when the hair got long enough. No insecticides were used in these tests and the clipping appeared to cause no discomfort, even in very cold weather.

Insecticide dusts control sheep keds

In 3 years of research the Wyoming station found that dusting feeder lambs with insecticides controlled sheep keds but did not increase the gains of the ked-controlled over the non-ked-controlled lots. Although infestation of keds was moderate to heavy on the lambs at the start of the trials, ked numbers on the untreated lots soon declined after the lambs had been on feed for several weeks. This was in contrast to increasing numbers of keds on range flocks at the same time of the year.

The fact that the sheep ked feeds on its host by withdrawing blood is sufficient evidence that the keds uses energy of the host and causes some changes in the energy relations. Apparently, however, these changes are not great enough to be reflected in the growth of feeder lambs when the infestation of sheep keds on untreated sheep declines after 4 weeks, as was the case with the feeder lambs. From a practical standpoint the study presented no evidence that a saving could be made by controlling keds on feeder lambs.

Cattle grub control

The cattle grub causes an annual estimated loss of millions of dollars to the beef and dairy industries of the nation. The pest is

often held responsible for a drop in milk production during the grub season. Moreover, millions of pounds of meat are lost annually because the flesh around the encysted grubs—known as jellied beef—must be trimmed out and discarded. A cowhide with many grub holes is considered worthless for tanning and is commonly sold for byproducts, and even a few holes usually result in a lower price.

The parents of cattle grubs are heel flies that glue their eggs to the hair on the legs and flanks of cattle. In attempting to avoid these flies, cattle run wildly about the pasture or range. The female fly may begin laying her quota of from 300 to 500 fertile eggs on cattle 20 minutes after mating, or only slightly more than an hour from the time of emergence from the pupal case. When the eggs hatch, the tiny larvae enter the skin of the animal. In the animal tissues the larvae move about for 9 months until they reach the loin area on the back of the animal where they make a breathing hole through the hide. Soon a cyst forms around each larva where it stays until it drops from the animal's back to the ground to pupate and emerge as a fly the next year. Rotenone applied to the infested area on the back is generally used for the control of cattle grubs. When properly applied this kills the grub and usually hastens the healing of the animal's back. No other benefits can be expected until the year after treatment. Killing the grub breaks the life cycle of the pest and reduces the fly population during the following season.

Research of the South Dakota station (coop. USDA) has shown that applying rotenone by hand as a wash to the infested area of the back was the most effective method of application and killed 85 to 90 percent of the grubs. In this method 5 percent rotenone powder, and granulated laundry soap are mixed in water. From 1 pint to 1 quart of this mixture is poured slowly on the back of the animal and thoroughly scrubbed into the hair coat with a stiff, long-bristled brush. Spraying killed 75 to 85 percent of the grubs, and dusting killed 68 to 70 percent. The latter two methods are more rapid and require less labor than the hand wash method.

The South Dakota station (coop. USDA) also reported that area control—treating all infested cattle in a locality—was effective. In one treated area centrally located herds showed a grub reduction of 67 percent below untreated herds immediately outside of the area. Herds located on or near the edges of two treated areas showed a reduction of grub infestation below untreated herds, but the percentage of reduction was not as large as it was in the center of the areas. A cheap, easily applied, effective control of the grubs before or soon after the young larvae penetrate the skin is needed.

Tick control

Ticks not only suck blood from farm animals but also are carriers of diseases, including anaplasmosis. Research at the Oklahoma station to reduce tick damage showed that area spraying of pastures with toxaphene at the rate of 2 pounds per acre reduced the tick population on cattle using the pasture to one-tenth for over a year, but that the cost of application was high. Larvae and adults were more easily controlled than nymphs. A 4-year study of pasture rotation as a method of reducing tick infestation showed that *Amblyomma americanum* (L.) ticks were reduced 75 percent the first year by this method.

The greatest gain since was an additional 7 percent even though pastures were kept free of cattle. More than 20 hosts of this tick were found in the pasture, which probably explains the lack of effectiveness of rotation as a preventive measure. Studies are in progress with materials applied to the animals as repellents and acaricides.

Stablefly control

Three years of research at the Nebraska station have shown that cattle can be protected against stableflies, but not against hornflies, horseflies, or deerflies, by direct applications of piperonyl butoxide-pyrethrins sprays that completely cover the animal. Control was about the same with all types of equipment when good coverage was obtained. The most economical formulation tested from the standpoint of time and material was the diluted emulsion concentrate, 1 part in 15 parts water, applied twice weekly to wet the animals completely. Less frequent applications were not as effective. The undiluted emulsion concentrate was applied effectively with the atomizer-type sprayer. The emulsion was applied daily in quantities sufficient to wet the hair tips but not the animal's skin.

Sprays control houseflies in dairy barns

With the development of resistance to DDT and other insecticides by houseflies infesting dairy barns, research on the housefly has centered around alternate control methods. The research of the Wisconsin station has shown that malathion did a thorough job of fly control even in a year of heavy fly infestation. In the Wisconsin tests a dose of 10 pounds actual malathion per 100 gallons of a 10-percent sugar solution was applied. Where sugar solution was not used, the control period did not last as long. Walls, ceilings, and other favored fly resting sites of the barn interior were sprayed so heavily that the material almost ran off. The station workers report that malathion spray should not be applied directly on animals or in milk houses. Tepp (tetraethyl pyrophosphate) was also effective when mixed with a sweetening agent and applied to floors and in gutters, but its toxicity to flies lasts only a few hours. It is highly toxic to warm-blooded animals and man.

Water conservation and mosquito control

The conservation of water in ponds and reservoirs for irrigation and other farm purposes may lead to the development of mosquito breeding of serious proportions. In its research on mosquito control under such conditions the North Dakota station found that adult mosquitoes and blackflies were effectively controlled for a period of 6 weeks by aerial spray applications of 1 pound actual DDT per acre over municipalities at a cost of 8 cents per capita for each application. At this rate the insecticide had no appreciable injurious effects on birdlife, goldfish, or honeybees.

To cut the cost of control the attack was shifted to the larvae. Larviciding impounded waters, such as sloughs and irrigation ditches, within a 6- to 8-mile periphery of Fargo proved to be an economical and effective means of reducing the number of adult mosquitoes invading the city. Larviciding of 316 acres that comprise the breeding

areas within a radius of 6 to 8 miles of Bismarck also eliminated the mosquito populations normally breeding in impounded waters. All insecticides used (Aldrin, Chlordane, DDT, and Toxaphene) were equally efficient in controlling the mosquito larvae. Before mosquito control was started about 90 percent of the mosquito infestation in Fargo one year was *Aedes vexans* which was the most annoying species. Only about 3 percent were *Culex tarsalis* mosquitoes, but this species is a carrier of encephalitis. Since mosquito control programs were started, the annoyance from mosquitoes has been greatly reduced in both treated areas, and there has been a very low incidence of encephalitis in Bismarck and Fargo as compared with the remainder of the State.

Internal Parasites

Liver fluke

During the past 50 years there have been at least 19 cases of human infection with cattle liver fluke in the Hawaiian Islands. It is also believed that many additional cases were never recognized. Although the source is not known, it is reasonable to assume, on the basis of the life cycle of the fluke, that the infections resulted from ingesting larval flukes encysted on vegetation grown in water. Since watercress is grown in water and is commonly eaten raw, it was thought that it might constitute a source of infection if grown in contaminated water.

On the basis of this suspicion, all the commercial watercress-producing areas on the islands of Oahu and Hawaii have been studied by the Hawaii station to determine the source of water used, the possibility of pollution with feces of cattle, and the presence of lymnaeid snails infected with liver flukes. Of 9 areas surveyed in Hawaii, all contained lymnaeid snails, 5 showed evidence or possibility of pollution, and in 1 area about 5 percent of the snails examined showed heavy infection with liver flukes. Of 13 areas on Oahu, 10 contained lymnaeid snails, 8 showed evidence of pollution, and none of the snails examined showed fluke infection. The present survey has shown that risk of watercress infection with liver flukes does exist in the Territory. This risk can be reduced if watercress growers abstain from the use of stream water which is likely to be infected, utilizing only spring water at its source of origin; lymnaeid snails are controlled; cattle are prevented from grazing in or near watercress areas; and fluke control in cattle is promoted to reduce infection in nature.

Fireflies may control flukes

It is possible that fireflies from Japan may be used to control certain small fresh-water snails which are the only carriers of the cattle liver fluke, a damaging parasitic disease of cattle as well as a potential threat to man in the Hawaiian Islands.

In recent years, the Hawaii station has been interested in reports by Japanese scientists that the larvae of two species of firefly, *Luciola cruciata* and *L. lateralis*, feed actively on fresh-water snails, some of which are known to be carriers of flukes. The beneficial nature of the fireflies is accepted, although some scientists feel that they do not kill enough snails to be effective. With their possible value in mind, the

Hawaii station (coop. USDA) imported 6,000 fireflies representing both species and released them in a number of swampy areas in the Islands. There are no other fireflies in Hawaii.

The larvae of the fireflies make tiny slashes in the soft snail when it emerges from the hard shell, and introduce a paralyzing agent that keeps the snail from drawing itself back into its shell. The flesh becomes liquefied and the firefly larva "drinks" its meal. In the course of its life one larva may kill a number of snails. If climatic and other conditions are not too different between Japan and the Hawaiian Islands the fireflies will adapt themselves to their new environment and multiply. If they become established it will be some time before their effect on snail populations and the incidence of liver fluke infestations in cattle becomes evident.

Pasture-parasite relationship

The Georgia station observed a marked increase in the infection by parasites of nursing calves kept on late summer pastures. This apparently is associated with a decrease in or cessation of milk production by the dams of these calves, and a lowering in the quality and quantity of pasture herbage available. Late summer and fall appears to be the time when calves may need treatment for parasite control, or when special provision should be made for a nutritionally adequate grazing-feeding program for the calves.

Yearling beeves at this station became severely infected by internal parasites on tall fescue pastures. They finished out poorly and sold at lower prices than cattle on crimson clover or on a temportary winter pasture of mixed grasses. Supplementary feeding of corn decreased internal parasitism in the cattle on all three types of winter pasture and permitted them to make normal gains and acquire a finish on fescue grazing.

Spring-dropped, younger calves as a group had over three times as many worms at post mortem as fall-dropped calves. The spring calves on crimson clover and on temporary winter pasture in 1952–53 had worm infections as high or higher than the spring calves on fescue. The spring calves on crimson clover and temporary winter pasture gained faster and showed little or no parasitic pathology, whereas the spring calves on fescue made poor gains and showed pathology of the stomach indicative of severe parasite infection. It appears that the relatively poor nutritive value of fescue grass predisposed the animals on that type of grazing to the harmful effects of parasitism.

Parasite-free calves of 5 and 6 months of age at the North Carolina station picked up heavy parasite populations from paddocks that had been heavily parasitized for 5 years and then left idle for two winters and a grazing season. Prolonged drought periods made overgrazing more severe. The calves were undernourished and appeared not to have even normal resistance to parasitism. All of the species of parasites previously found on these paddocks were present in sufficient numbers to develop parasitism in young calves.

It was evident under these conditions that the period when the paddocks were host-free was too short to free them of the parasite populations to a point where they were safe for young calves. It was also evident that young calves can harvest too many parasites when

grazing and that care should be taken that calf pastures carry a minimum parasite population or, better still, that calves be kept in dry lots, free of vegetation.

Phenothiazine therapy in cattle

Experiments at the Louisiana station on the prevention of losses due to parasitism in calves by low-level feeding of phenothiazine in the grain ration, indicate the following facts in pure infections of the large stomach worm (*Haemonchus contortus*). When calves are fed phenothiazine at the rate of 1½ grams per day, eggs usually cease to be found in the manure within about 2 weeks. In all animals the eggs become abnormal in about 48 hours after phenothiazine feeding is begun and infective larvae are not recovered from the manure. Under phenothiazine treatment future infections are prevented and protection is afforded to the younger, more susceptible animals. Similar experiments gave comparable results in cases of pure infections of the nodular worm and hookworm.

When the drug is fed during the first 2 weeks of the prepatent or larval period of the parasite within the calf, it does not cause interference with the normal development of the larvae in these early stages. Thus the symptoms of parasitism and the losses will not be prevented when the larvae are already on the premises and infections induced by the larvae are evident at the time the feeding of the drug is begun. Previous experiments have demonstrated also that phenothiazine offers no protection from symptoms in pure infections of the nodular worm.

Phenothiazine given to healthy suckling calves nursing cows on an adequate diet did not retard gains, according to a Texas station report.

Additional evidence that use of phenothiazine in feed constitutes a more effective treatment for lungworms in cattle than any drug now available, and that continuous low-level dosage of phenothiazine in feed does not affect palatability, is being obtained in Oklahoma station trials.

Parasitic damage to swine livers

Internal parasites of swine cause a heavy annual loss to the meat industry. A study made by the Virginia station revealed that two-thirds of the livers from 33,655 hogs slaughtered over a 12-month-period at three federally inspected abattoirs in southeastern Virginia were condemned as unfit for human consumption because of parasitic damage to them. This resulted in an estimated loss of 60.5 cents for every hog slaughtered.

Swine ascarid eggs persist in the soil

Approximately 2 years after a ¼-acre pasture at the Michigan station was seeded with Ascaris eggs six young pigs were run on this pasture and then were sacrificed at 2-week intervals. All of these pigs had extensive liver scars due to worm migration. Three littermates held on Ascaris-free concrete floors, however, did not develop liver lesions. This confirms results of an earlier study conducted by the Department. Thus the popular idea that hog lots not used for 2 years are safe from this form of parasitism is subject to considerable doubt.

Swine kidney worm

Up to the present time there is no known drug that will safely and effectively destroy kidney worms in swine. Studies were therefore conducted at the stations in Hawaii and South Carolina to determine the efficacy of certain chemicals in killing the larvae in soil. Results of the study at the Hawaii station strongly suggest that "Polybor-3" a combination of sodium pentaborate tetrahydrate and sodium tetraborate pentahydrate, will enable hog raisers to make an already infected hog lot comparatively free of kidney worm larvae, and by frequent application to reduce materially the level of kidney worm larvae in soil on which infected animals are kept. The station notes that this chemical combination is injurious to plants and, therefore, should not be used where vegetation is to be maintained. The South Carolina station reports that soil treatment with delta isomer benzenehexachloride will reduce kidney worm infection in young swine if the infected pens or lots are treated once weekly until the pigs are weaned and they are transferred to kidney-worm-free lots.

Resistance of sheep and goats to stomach worms

Experiments aimed at raising the natural resistance of sheep and goats to the common stomach worm *Haemochus contortus* have been in progress at the Texas station for many years. Early selections of surviving animals raised without anthelmintic treatment on intensive exposure pastures have resulted in a flock of each species able to withstand this parasite. The survival rate in lambs has been raised from 11 to 85 percent in a 9-year period. This high survival occurred only when both parents were tested, as lambs with only one tested resistant parent were little different from unselected controls. When goats that had survived the exposure test were bred to individuals that were selected for stomach worm resistance or to unselected controls, the survival rate was high (above 75 percent), evidence that goats are more resistant to this parasite than sheep. In both species it is possible to raise the level of natural resistance to the point where it will be economically feasible to use parasite-resistant breeding stock for commercial production.

Neurofilariosis

The New York (Cornell) station has studied a disease of lambs characterized clinically by lameness or paralysis originating in the central nervous system. Affected lambs came from widely separated areas of the State. When examined at the station they had a nearly complete motor paralysis of neck, trunks, and front and hind limbs. A new species of filaria, *Neurofilaria cornellensis*, was found in the brain and spinal cord of two sheep.

Sheep parasites also persist on pastures

A special plot at the Missouri station that was heavily contaminated with parasite eggs and larvae was withheld from sheep for two winters and the intervening season. When parasite-free lambs were placed on this plot, it was proven from the subsequent infection of the animals that eggs from at least eight different parasite species had survived.

The station also reports that it was able to culture sheep parasite larvae and infest calves with them, and then to transmit those parasites back to sheep from the calves. This indicates the danger of sheep parasites to other ruminants.

Cobalt and parasitism

A very small amount of cobalt is necessary to the health and normal growth of cattle and sheep. The effects of a lack of this amount of cobalt appears more quickly in sheep. Experiments are in progress at the Virginia station to determine whether or not the presence of a sufficient amount of cobalt or a deficiency in the daily amounts of food consumed bears any relationship to the degree of parasitism maintained in the animals. Although the results are incomplete they indicate that greater numbers of eggs per gram of feces were found in animals on an adequate cobalt diet than in the unsupplemented animals, but that the former made greater gains in weight.

Continuous phenothiazine therapy for horses

A long-term study of low-level phenothiazine administration to horses has been in progress at the Kentucky station. The experiment was planned to determine its possible toxic manifestations and its therapeutic activity against parasites harbored by horses. Daily doses of 2 grams of this drug were continued through 4 years. No manifestation of toxicity was noted in any of the animals. Monthly fecal examination for strongyle eggs showed consistently negative or low order counts. However, on post-mortem examination relatively large numbers of both large and small strongyles were found in the large intestine of two of the mares. This apparent discrepancy served to emphasize the effectiveness of the action of the drug in low-level dosage. At this level it inhibits egg production by strongyles, even though it is ineffective in removing mature strongyles from the intestinal tract or in preventing development of mature strongyles from infective larvae which may be ingested by the horse.

Blackhead in chickens and turkeys

At one time, blackhead (infectious enterohepatitis) in chickens was considered to be a benign disease and of no economic importance. After vaccination against fowl pox became a common practice, however, a change was noted. Although a flock appeared to be in good health at the time of vaccination, heavy losses were suffered from blackhead, usually beginning 10 days to 2 weeks after vaccination and continuing for 10 days or more. Later, heavy losses from blackhead began to occur in the absence of any prior history of fowl pox vaccination.

The efficacy of Enheptin (2-amino, 5-nitrothiazole) in the treatment and prevention of blackhead of turkeys caused by *Histomonas meleagridis* has been demonstrated by the Storrs (Connecticut) (1950) and Maryland (1951) stations. These stations reported that, except for a short period of retardation in the growth of the turkeys due to depressed feed consumption, no toxic effects were noted. Enheptin thus appeared to meet the need for a drug that would help prevent

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losses from blackhead in chickens. However, this did not prove to be the case. Feeding Enheptin to 12-week-old White Leghorn cockerels at therapeutic levels of 0.1 percent for 2 weeks, and at 0.05-percent level during the third week at the New Jersey station resulted in a complete inhibition of sexual maturation in these birds. Feeding cockerels Enheptin caused a reduction in the size of comb and a shriveled comb structure, a reduction in the size and activity of the testis, infertility, and generally complete sexual regression. In later research, a daily average drug intake of 41.0 milligrams was found to be sufficient to cause complete suppression of sexual development of both pullets and cockerels. When treatment was discontinued, both males and females required approximately 10 weeks to recover from the drug effects.

Preliminary experiments at the Michigan station have indicated that chick or turkey embryos are not suitable environments for the growth of the blackhead organism. This contributes further evidence against the hypothesis of certain workers that the organism can be transmitted by the avian egg.

In continuing its experimental work with bacteria-free suspensions of *Histomonas meleagridis*, the Maryland station has shown that the parasite is not dependent on associated bacteria for its pathogenic effect.

Large roundworms of fowls

Little is known of the effect of some parasites on their hosts. Experiments have been conducted by the Michigan station on the effect of *Ascaridia galli* infections on the thymus gland in chicks in the presence and absence of vitamin B_{12}. The results clearly indicate that these roundworm infections induce a thymic atrophy in the bird either in the presence or absence of vitamin B_{12}. Although this atrophic condition results from the vitamin deficiency alone, it is more pronouced when the birds are infected with the parasite.

Experiments were conducted at the Kansas station to determine effects of aureomycin and/or vitamin B_{12} (at levels used in commercial feeds) on the resistance of chickens to *Ascaridia galli*, the large roundworm of fowls. Aureomycin or vitamin B_{12}, or a combination of both, reduced the incidence of infection and lowered the mortality rates resulting from ascariasis among the experimentally infected chickens. The addition of aureomycin and vitamin B_{12} to an all-plant protein basal diet significantly stimulated the growth of the chickens, whether they were parasitized or not. Of particular importance, however, is the fact that there were no significant differences in the weight gains made by parasitized versus nonparasitized chickens fed only the basal ration, whereas parasitized chickens fed the supplemented ration made significantly inferior weight gains as compared with weight gains of the nonparasitized chickens fed the supplemented ration. The increased growth rate of the nonparasitized chickens fed the fortified diet places increased importance on ascariasis. Some evidence was shown that ascariasis likewise decreased the feed efficiency of the fortified feed. Accordingly, if poultrymen and farmers are to obtain maximum growth responses from feeds fortified with these supplements, they must continue to use known control measures against the large roundworm.

Coccidiosis

During the past 25 years poultrymen have known that in nearly every brood of chicks, bloody diarrhea, or cecal coccidiosis would appear. Losses of one out of every two birds were not uncommon. With the discovery of the sulfa drugs and other medicants, control of coccidiosis became a possibility. Continuous treatment, however, is costly and success of periodic treatments depends on early detection of the disease. As a result of experimental work at the Alabama station poultry raisers may now vaccinate chicks for cecal coccidiosis at 3 days of age by feeding them the vaccination material which contains live agents (oocysts). The chicks develop immunity by getting the disease in such a mild form that it does not harm them but prevents later trouble. The material is mixed with wet mash so that all chicks can eat and clean it up at one time; it costs about 1 cent per bird, and administration takes about half an hour for a thousand birds. Thirteen days after feeding the vaccinating material, a sulfa drug is administered in the drinking water as a safeguard against the immunization procedure getting out of control. This, as has been stated, is for control of cecal coccidiosis. Further studies are in progress for possible control of other types by immunization.

Although improved management, treatment, and preventive measures have reduced the incidence of this form of parasitism considerably, the Alabama, Hawaii, and Wisconsin stations are attempting still more effective control through breeding. This year at the Alabama station, only about one-fourth of 497 sixth-generation White Leghorn coccidiosis-resistant chicks in five replications, artificially tested at 2 weeks of age with *Eimeria tenella*, died as compared with the deaths in a group of 194 chicks from unselected parents. The Hawaii station presents some clear-cut evidence that mendelian factors do influence the chick's ability to survive an artificial infection of cecal coccidiosis.

The Wisconsin station reports that tests on seven highly inbred strains of Single-Comb White Leghorns showed that 70 percent of the chicks of one strain survived coccidiosis, whereas only 9 percent of the most susceptible strain survived. The other five strains were intermediate in resistance to the parasite.

As a result of early research at the Ohio station, built-up litter has been widely proclaimed by poultrymen during the past several years as the answer to many of their disease problems, especially that of cecal coccidiosis. By the term built-up litter is meant the continued rearing of successive groups of young chickens on the same litter without any change except an occasional stirring or removal of either the litter or feces until the material becomes 8 to 12 inches deep. It has also been recommended that hens can be maintained on the litter and later a new crop of baby chicks raised on the same litter. The addition of hydrated lime as needed, to aid in keeping litter more friable, more absorbent, and less inclined to paste or cake over, has become a standard practice.

The Ohio station found, however, that the oocysts of *Eimeria tenella* will survive equally well in hydrated-lime-treated built-up litter and unlimed built-up litter. Present work by the same station reveals that both parasite ova (*Ascaridia lineata*, *A. galli*, *Heterakis gallinae*, and *Capillaria retusa*), and oocysts (*Eimeria tenella*, *E. acervulina*,

and *E. maxima*) are viable in built-up litter, as shown by the presence of the adult parasites and coccidia in the intestinal tracts of chickens reared on the litter. The station concluded that rearing young chicks on the same litter that old hens have used can result in a very grave parasite problem. Hens that have parasites are constantly contaminating the litter with ova and oocysts so that the baby chicks placed on this hen litter are very susceptible to both nematode parasites and coccidia.

The Hawaii station found that fly larvae can ingest oocysts and transmit coccidiosis if the larvae are eaten by chicks. The larvae apparently are freed from oocysts during pupation, so that the newly emerging flies are not infectious. However, adult flies can ingest oocysts and then transmit infection for about two days, either by being themselves ingested or through the ingestion of their feces. Feces from such flies have been found to produce severe coccidiosis in chicks when collected within 24 hours after the flies were exposed to infection. Feces collected after 24 to 48 hours produced light infection and when collected after 48 to 72 hours produced infection in one experiment and none in another. So it is possible for flies to transmit severe coccidiosis to chicks if they contaminate animal feed or water soon after they have been exposed to heavy coccidial infection.

Through a study made under poultry farm conditions to determine to what extent houseflies may be responsible for spreading coccidiosis and other poultry parasites, the station concluded that under ordinary conditions coccidiosis is transmitted by flies only occasionally but that the incidence of coccidiosis among flies may be sufficient to spread and maintain a constant infection among native birds.

Poisonous Plants

Pasture and hayland management improvement in the humid areas has reduced animal losses from poisonous plants to negligible proportions. Most poisonous plants are not palatable, except possibly in their young and succulent stages, and if grazing animals are provided with a good pasture they seldom consume such plants in sufficient quantities to cause injurious effects.

Certain tropical legumes, principally trailing indigo are toxic to animals. Strains of this plant vary widely in toxicity and progress is being made in developing nontoxic strains. The Hawaii station has developed a rapid chick-assay test for checking the toxicity of trailing indigo and other tropical legumes. Dry meal is produced from the plants and substituted for alfalfa meal in the chick starter ration. If the plants are toxic, the chicks develop typical symptoms within 21 days.

Toxic plants present a serious problem on the more arid rangelands and frequently cause serious animal losses, especially in localized areas.

The Arizona station has found that late fall and spring are the two seasons when poisonous plants cause greatest losses in livestock. If winter rains are heavier than normal there is usually an abundance of succulent weeds that may cause bloating or poisoning from nitrates, oxalates, and other toxic substances. If there is low rainfall grass and weeds are in short supply and range animals tend to graze toxic shrubs. There are few antidotes for most poisons and losses usually

occur so rapidly that treatment cannot be effective. Good management and close observation are the most eflective means of reducing losses from poisonous plants. Supplemental feed will usually prevent animals from grazing the unpalatable poisonous plants.

Halogeton has received more recent attention than any other poisonous range plant and several of the western stations have been doing research on it. Studies by the Utah station show that animals can graze ranges heavily infected with halogeton if they are handled wisely. Dense patches should be avoided but sparse stands, in mixture with other vegetation, ordinarily can be grazed without danger, provided they are not overgrazed and the animals are allowed to spread out and graze normally. It was found that as much as two-thirds of the diet can be composed of halogeton without harmful results if the plant is consumed slowly over a day's time with other feed.

The Colorado station reports that a range plant called Lithospermum, growing on Western Slope dry lands, is thought to affect the fertility of livestock when eaten, thus lowering the calf and lamb crops. The plant is being collected for further analysis and testing.

ANIMAL HUSBANDRY RESEARCH

Experiment station research in livestock breeding, nutrition, physiology, management, and related phases is contributing materially to improvement in the quality and productive efficiency of the various species of livestock. The research is directed: (1) Toward specific and immediate problems affecting the production of beef cattle, sheep, and swine; and (2) toward the development of basic knowledge needed in evolving more effective breeding methods, and a clearer understanding of physiological processes and nutritional requirements of farm animals under varying environmental conditions. These fundamental studies provide the necessary foundation for future research on practical problems. A few examples of the progress of research in animal science are given here.

Beef Cattle

Improving efficiency of beef production

Research at the Ohio station has shown that additional minerals may be needed in feeding low quality roughages to beef cattle. Average daily gains of steers fed a conventional fattening ration and late-cut timothy hay were increased significantly by adding alfalfa ash or a combination of iron, copper, cobalt, manganese, and zinc to the ration. Equally good results were obtained by adding 1 pound of cane molasses or the ash from a pound of molasses. Urea, plus 1 pound of molasses, satisfactorily replaced one-half of the soybean meal, but was less valuable as a source of protein (nitrogen) when fed with good quality roughage. Rations containing good roughage were superior to any of these.

Although grass silage is an excellent feed for cattle, it has certain nutritional deficiencies that should be corrected by adding suitable supplements to obtain maximum feeding value. Steers fed a mixed legume-grass silage plus minerals, by the Indiana station, gained only 0.32 pound daily at a cost of 50 cents a pound. The addition to the

silage of a special supplement composed of alfalfa meal, molasses, dried brewers' grains, and certain minerals increased the daily gain of these steers to 1.09 pounds at a cost of only 20 cents per pound of gain. The silage required to produce a pound of gain was reduced from 102 to 31 pounds by use of this supplement. Previous research had shown that preserving grass silage with corn materially improved its feeding value.

Feeding experiments conducted by the Colorado station show that dried beet pulp can replace up to half of the corn in a fattening ration, with about equal feeding value, and a savings in total feed cost.

At the Illinois station, yearling steers full-fed high protein corn (14.1 percent) and silage made from high protein corn gained as rapidly and efficiently as similar steers fed regular corn and corn silage plus 2 pounds of soybean meal.

Through efficient use of good quality roughage and pasture, the Missouri station produced choice 2-year-old slaughter cattle with much less grain than is normally used. Choice yearling steers wintered on corn silage and lespedeza hay, and summer grazed on wheat-lespedeza pasture required only 10.7 bushels of corn plus supplement, with a feeding period of 48 days to reach choice grade. Other steers wintered on bluegrass and lespedeza made little gain. Although these steers gained rapidly on summer pasture, they failed to overcome the weight difference due to winter treatment. Steers summer grazed on a combination of wheat and lespedeza gained 42 percent faster and averaged a grade higher than those grazed on a mixture of fescue and ladino.

The Idaho station has made a study to determine the optimum proportions of concentrates to alfalfa hay for fattening beef cattle. The most economical ratio of concentrates to hay for average price relation was found to range between 2:1 and 1:3 for steer calves, and between 1:1 and 1:3 for yearling steers. Steer calves consumed from 716 to 934 pounds of feed for each 100 pounds of gain, whereas yearling steers required from 998 to 1,246 pounds of feed, depending on the ratio of concentrate to hay used.

At the Colorado station steers made the most economical gains when the ratio of concentrates to roughage was increased at 4-week intervals during the feeding period. These steers also had higher carcass grades and dressing percentages than other steers fed concentrate to roughage ratios of 1:2, 1:1, 2:1, or 3:1 throughout the feeding period.

The Utah station found that feeding sucrose to beef cattle and swine 3 to 6 days before they were slaughtered resulted in increased gains, improved the weight and flavor of their livers, and sometimes increased their dressing percentage. The response of individual animals varied considerably. Additional research is in progress to determine optimum levels of sucrose and length of feeding period for best results.

Breeding and selection

Research in the improvement of beef cattle through breeding, involving cooperation between the Department and the agricultural experiment stations of 39 States and Hawaii, has continued with encouraging results. A current problem is that of finding faster ways

of improving productive efficiency and carcass quality of beef cattle under different environmental conditions.

The weaning weight of the calf is an important factor in evaluating cow performance. The Oklahoma station (coop. USDA) found that selection for weaning weight could be made more effective by correcting for the effects of certain environmental factors. The age and sex of the calf, the age of its dam, and the year in which the calf was raised were important factors governing weaning weight. Cows tended to repeat their performance, which indicates that females can be culled for mothering ability on the basis of their first calf record.

The New Mexico station (coop. USDA) demonstrated that calf grade at weaning age is not associated with subsequent gain in the feed lot or carcass grade. Yearling feeder grade had a low but significant influence on carcass grade. On the other hand, the gains made by cattle on feed were found to be closely related to the live grades and carcass grades of fat cattle. The results of the New Mexico study give additional proof that selection of cattle for gaining ability can benefit both the breeder and feeder.

The Montana station (coop. USDA) learned that heifer progeny groups wintered on a good growing ration ranked in the same order for rate of gain as full-fed steer progeny sired by the same bulls. Results of a 7-year comparison of feed-lot gains with gains on good range indicate that the sire progeny that made highest gains on pasture also gained more in the feed lot. This supports earlier results at the New Mexico station.

Through the use of performance-tested bulls, the Oregon station (coop. USDA) has been able to bring about considerable improvement in the rate and economy of gain in each of their Angus and Hereford lines within a single generation of cattle, even though some inbreeding was practiced. The improvement in rate of gain, ranging up to as much as 30 percent for some bulls, was greater than the improvement in feed efficiency. In performance testing, bull calves are generally fed for a period of about 180 days. The station found that records on feed efficiency of calves can be evaluated more critically when the animals are fed to make a given amount of gain. For calves fed on this basis there was a significant correlation between time and feed required to make the gain, whereas there was no correlation between gains and feed consumed when calves were fed on a time constant basis.

The Utah station (coop. USDA), found that efficiency of gain is influenced significantly by weight of the calves at the beginning of the feeding period as well as by sire and sex. With increase in size, calves tend to gain faster but less efficiently.

At the Colorado station (coop. USDA) crosses of inbred Hereford lines resulted in calves that were 12 percent heavier at weaning and 11 percent higher in grade than inbred calves sired by the same bulls and out of inbred cows. Bulls produced from the crossline matings were also heavier and graded higher at yearling age than inbred bulls. In cooperators' herds, inbred sires produced calves that averaged 19 pounds heavier at weaning than the progeny of selected outbred bulls. If substantiated by later results, these methods should prove valuable as a means of increasing productivity of beef herds.

Swine

Progress in breeding research

Swine breeding research results continue to emphasize the importance of hybrid vigor in swine. This is obtained by crossing breeds, and inbred lines within breeds or between breeds. Hybrid sows and gilts generally have shown improvement in reproductive performance, in growth rate, and in liveability and carcass quality of their pigs compared with outbred sows. The large surplus stocks of lard and other animal fats already available and the preference of consumers for leaner pork, are among the factors responsible for increased emphasis on the improvement of carcass quality as well as the reproductive performance and overall efficiency.

At the Illinois station (coop. USDA) linecross sows mated to inbred boars farrowed and weaned significantly larger litters than were obtained in conventional outbred matings. The linecross pigs averaged almost 6 pounds heavier at weaning than those farrowed by outbred sows, and averaged 322 pounds more in their 154-day litter weight than those produced by outbred sows. Carcasses of linecross barrows were generally leaner and longer, and had less backfat than outbred barrows of similar weight.

Litters of crossbred pigs produced by mating inbred boars to outbred sows of cooperating farmers by the Pennsylvania station (coop. USDA) were heavier at weaning, gained faster, and reached a market weight of 225 pounds in 158 days, compared with 176 days for purebred pigs. The crossbred litters were slightly larger at weaning but showed no advantage in number farrowed, percentage farrowed alive, or birth weight over outbred litters.

Contrary to the opinion that either crisscrossing or continuous rotational crossing of lines or breeds increases variability in performance and tends to "run out," the Minnesota station (coop. USDA) reports that these methods were effective in maintaining and improving on the advantages of hybrid vigor obtained in first crosses.

A rotational crossbreeding system, in which inbred boars of four breeds were used by the South Dakota station (coop. USDA), has resulted in animals of early sexual maturity, high conception rate, superior litter size, and superior gaining ability, compared with outbreds or linecrosses within a breed.

Detailed carcass studies by the Oklahoma station (coop. USDA) have shown that there are large hereditary differences in carcass merit. The results also clearly show that rate and efficiency of gain need not be sacrificed in breeding for improved meat quality and carcass value. In line-cross progeny no important relationship was found between rate of gain and carcass value, or between efficiency of gain and carcass value. For example, three litters that made 100 pounds gain on only 304 pounds of feed had carcass values equal to four other litters that consumed 373 pounds of feed for 100 pounds of gain.

A study of records on about 3,850 gilt litters made by the Wisconsin station shows that crossbred litters have lower death losses than litters from gilts bred to boars of the same breed. Although litter size at birth and individual weaning weights were about the same for the two systems of breeding, litters from crossbred gilts averaged almost 100

pounds heavier at 5 months than the litters from straightbred gilts.

By practicing moderate inbreeding and critical selection of progeny in an experiment designed to obtain high performance characters, the Louisiana station has developed a herd of Durocs that farrows and weans large litters, with good growth rate and a high feed efficiency. In 1952, 93 percent of the litters qualified for production registry, with an average of 9.5 pigs weaned per litter and an average weight of 40.8 pounds at 56 days.

Advances in baby pig nutrition

Better knowledge of swine nutrition through research and improved systems of management and rations for raising baby pigs, now being developed by some of the State agricultural experiment stations, are contributing toward improved litter performance and more efficient production. Current weaning weights on farms average about 28 pounds. At the Iowa station, pigs permitted to nurse their mothers for only one week, then fed a limited quantity of synthetic sow's milk along with a dry, sugar-coated, pelleted pig starter until they were 8 weeks of age, averaged 63 pounds at 56 days and made this growth on 1.78 pounds of feed per pound of gain.

The Illinois station reports that supplemental creep-feeding of suckling pigs, either under dry-lot or pasture conditions, results in more rapid growth and heavier pigs at weaning. Pigs weaned at 7 weeks of age and continued on a mixed pig starter improved their weaning weight by about 4 pounds under dry-lot conditions. When sows and litters were grazed on rye pasture and self-fed shelled corn and supplement, creep-fed pigs out of these sows gained 20 percent faster than those not creep-fed. Hulled oats and pig supplement, dry artificial milk, or a mixed pig-starter ration were all equally effective in producing more rapid gains. Contrary to what might be expected, daily gains of pigs creep-fed rations containing 17 percent protein were as high as pigs fed rations containing 20 or 23 percent protein.

Improved rations for growing hogs

Research conducted by the Missouri station indicates that certain rations commonly fed to growing and fattening swine may be deficient in one or more of the B-complex vitamins. A corn and soybean oil meal ration when supplemented with riboflavin, pantothenic acid, and nicotinic acid produced 13 percent faster gains on weanling pigs than did the basal ration. The addition of these three B vitamins to a corn and tankage ration also improved the rate of gain and reduced the amount of feed required per 100 pounds of gain.

The Ohio station reports that a B vitamin concentrate or a natural source of B vitamins, such as dried distillers grain solubles, were equally effective in improving health, growth, and feed efficiency of pigs in dry lot. The pigs were fed an all-plant-protein type of ration fortified with trace minerals and an antibiotic.

The Nebraska station has found that 16 percent protein is adequate for weanling pigs fed a well-balanced ration containing vitamins and minerals. The protein level was reduced to 14 percent when the pigs averaged 75 pounds, and to 12 percent when the pigs weighed 125 pounds, and there was no loss in rate of gain or feed efficiency com-

pared with pigs fed higher levels of protein. The addition of aureomycin or a combination of aureomycin and B_{12} improved daily gains and feed efficiency.

At the Oklahoma station weanling pigs fed a 12-percent protein ration of corn and soybean meal supplemented with 0.1 percent of the amino acid DL-lysine made gains equal to those on a 16-percent protein ration. The additional lysine increased the rate of gain by 23 percent and reduced feed consumption per pound of gain by 19 percent compared with the basal ration. Similar findings were reported by the Iowa station.

Experiments at the Ohio station show that pigs fed a low protein ration, with or without an antibiotic, gained as rapidly and efficiently as similar pigs fed standard or high protein rations in winter, but not in summer. The pigs received protein levels of 12.4, 15.3, and 18.2 percent to a weight of 120 pounds, with a reduction of 2 percent in each level beyond the 120-pound weight. The standard and high protein rations produced leaner carcasses, however, than the low protein rations.

Experiments at the North Dakota station show that when properly supplemented, pulverized and pelleted barley and oat rations for growing swine were equal to corn on the basis of rate of gain and feed cost. Pulverizing and pelleting the grain improved palatability and feed consumption. Gains of as much as 2.2 pounds per day were obtained on several lots of pigs from 40 pounds to market weight of about 200 pounds.

Trials at the Nevada station show that growing pigs can utilize more roughage than is commonly believed. Crossbred pigs fed a ration containing up to 50 percent alfalfa made satisfactory gains with a saving of about 20 percent in feed cost. In these experiments 1 pound of alfalfa was approximately equal in feeding value to a pound of grain. Pelleting of the ration improved pig performance. The station recommends that at an early age pigs be started on a high roughage ration containing high quality alfalfa ground to suitable fineness.

Sheep

Lamb gains stimulated by plant estrogenic substances

At the Iowa station liveweight gains in lambs have been increased as much as 40 percent by supplementing the ration with estrogenic substances isolated from alfalfa and clover hay, and soybean oil meal. These substances were also effective in stimulating gains in cattle. According to these investigators, not all kinds of hay or rations contain sufficient amounts of these newly identified substances to bring about maximum gains in growing livestock. This research holds promise that these substances as well as others now available, such as stilbestrol, can be produced commercially so that they may be added to rations in optimum amounts for improving overall production of sheep and cattle.

Protein needs of breeding ewes

Is it profitable under farm conditions to feed concentrates to breeding ewes during late pregnancy? Missouri station research indicates that mature ewes wintered on good pastures do not require concen-

trates during the last 8 weeks of pregnancy if the ewes are well fed during lactation and the lambs are creep-fed grain. Although ewes fed a liberal allowance of concentrates in addition to pasture during late pregnancy dropped and weaned heavier lambs, the advantages were not sufficient to offset the higher feed cost. Omission of the concentrates during late pregnancy resulted in savings of from $3.50 to $5 per ewe at current feed prices.

Influence of environmental factors

When buying breeding rams that have been grown to breeding age under a high plane of nutrition, ranchers have difficulty in estimating the potential production of such rams under practical range conditions. The New Mexico station found that ram lambs grown in the feed lot for 10 months produced about 30 percent more clean wool, 12 percent longer staple, and were 20 percent heavier than similar rams grazed on the range. These results will aid ranchers in making proper allowance for the effects of some environmental factors.

Sulfur improves utilization of urea

Experiments conducted at the Illinois station with radioactive sulfur have shown that inorganic forms of sulfur can be utilized by sheep to form wool cystine. Body and wool growth of sheep fed a ration containing urea as the only source of supplemental protein (nitrogen) was increased significantly by the addition of small amounts of elemental sulfur, sodium sulfate, or methionine. In a practical wintering ration fed to ewe lambs, urea plus sulfur, with a readily available source of energy, replaced two-thirds of the soybean meal with no loss in weight gains or wool growth. Thus optimum amounts of sulfur may be of considerable importance to ruminants in utilizing rations containing nonprotein sources of nitrogen.

Crossbreeding for wool and lamb production

The Virginia station has compared western crossbred ewes, from four different sources, as replacement breeding stock for commercial lamb production. Texas blackface ewes, Northwestern blackface and whiteface ewes, and Northwestern Fine Wool ewes were mated with mutton-type rams of five different breeds. Two-year data indicate that the two kinds of blackface ewes gave about equally satisfactory performance as measured by lamb birth weights, gains, slaughter and carcass grades, and yields. Fine Wool ewes had fewer twins, and the lambs graded slightly lower than those of blackface ewes. Mortality rate was about the same for all groups.

In a similar study at the Mississippi station, Southwestern crossbred ewes sired by Suffolk and Corriedale rams gave slightly better overall performance than Northwestern crossbred ewes. The latter were sired by Columbia and Hampshire rams. Factors considered were early lambing, birth and weaning weights of lambs, percentage of lambs raised, and wool production of the ewes.

From an initial cross of Rambouillet ewes and Romney rams followed by backcrossing the progeny to Rambouillet rams, the Texas station is developing a fine-wool type of sheep that may be shorn twice a year, and still yield combing-length wool. Some sheep in the

experimental flock have produced fine wool 2¼ inches in length in 6 months. The sheep are now being interbred for selection and stabilization of the genes for long staple.

Under range conditions fine wool ewes mated to Columbia and Targhee rams by the Utah station (coop. USDA) weaned higher percentages of fat lambs at heavier weights than similar ewes bred to Rambouillet rams. The Columbia and Targhee sired lambs were also smoother bodied, more open faced, and had longer staple wool at weaning than those sired by Rambouillet rams. Percentage of ewes lambing, number born, and total production per ewe were similar for the three types of matings. The Utah station reports that lambing percentages and production of lamb per ewe in the southern Utah area have been increased materially by pasture breeding, shed lambing, and other improved practices adopted by sheepmen as a result of experiment station research.

Wool studies

Seven of the western State agricultural experiment stations in cooperation with the Department are developing methods and technical information needed by wool growers in evaluating the quality of their product, and in improving its market value through better methods of preparation.

After deducting grading charges, fine wools graded for length at shearing time by the Texas station showed an advantage of 5.3 cents per pound in selling price over similar ungraded wools sold at the same time.

Preliminary experiments in marketing grease wool in semiprocessed form as top and noils by the Wyoming station, indicate that this practice may have advantages for the wool grower. In these tests, six lots of graded Fine, ½ Blood and ⅜ Blood wools processed into tops and noils returned average profits above processing costs of 3.7 to 5.3 cents per grease pound.

A well-defined crimp in Fine wool is usually considered an indication of quality. The New Mexico station found that Fine Staple Wool with a low crimp ratio (length of crimp/depth of crimp) had a lower clean wool content, but yielded a higher percentage of top and less noils than wools with a high crimp ratio.

The Oregon station found that scouring the fleece tags before they were sold improved their market value 5 to 6 cents a grease pound, compared with the usual practice of selling them in the grease. At the Montana station, all off-sorts including tags, crutchings, and sweepings brought more when sold at the usual discount than when sold in scoured form. More research is needed on all of these practices before they can be recommended to growers.

DAIRY PRODUCTION

Animal Breeding

There are four regional studies in the United States having to do with the improvement of dairy cattle through breeding. The southern group of experiment stations is emphasizing heat tolerance in their animals. The eastern group is trying to eliminate diseases that

affect breeding efficiency. The western experiment stations are most concerned with the minimum nutritional requirements for normal reproduction, whereas the experiment stations in the central part of the United States have taken up the problem of concentrating superior germ plasm most effectively, or in other words, the problem of methods of breeding. The following excerpts from regional reports will help the reader to better appreciate the progress that has been made and the problems that still face the animal breeding specialist.

The Louisiana station has found no significant relationship thus far between heat tolerance and heritability. South Carolina is recommending that dairymen who own grade Guernsey and Jersey cows mate them first to Holstein bulls and then mate the progeny to Brown Swiss bulls if they wish to increase the milk production of their herds.

Dairy outcross heifers at the Minnesota station grew 20 percent more rapidly than inbred heifers up to 6 months of age. This does not mean that crossing inbred strains results in above average reproductive efficiency. In fact, the North Carolina station states, "It is evident that the application of genetic principles has little to offer in remedying most of the commonly encountered problems regarding normal reproductive efficiency." The New Jersey station found a tendency toward lower breeding efficiency in their dairy herd as the degree of inbreeding increased.

The Ohio station has sought to learn whether there is any correlation between thyroid activity of an animal and its ability to produce milk. This was done by measuring the protein bound iodine (PBI) in the blood. Significant breed differences were discovered. Among the animals studied, the breeds ranked from high to low as follows with regard to their PBI: Jersey, Guernsey, Brown Swiss, Ayrshire, Holstein, and the beef breeds.

According to data obtained with the South Dakota station experimental herd, cows which give birth to twin calves usually produce less milk the following year than cows which give birth to only one calf. The demand for identical twins as experimental animals is constantly increasing because differences in nutrition and management can be more readily measured when there are no interfering genetic differences. Although blood typing is still considered one of the most satisfactory methods of distinguishing fraternal twins from identical twins, the Minnesota station has found that blood type alone is not a conclusive diagnostic test of identical twins.

Calves

The more female calves he saves, the more cows the farmer will eventually have and the closer he can cull his herd for low producers. A bull calf is a potential source of superior germ plasm. Every effort is being made to safeguard the calf during the early critical period in its life. Last year a number of stations reported that calves fed aureomycin made better gains than those receiving no aureomycin. But this year the Illinois station reported that no benefit was derived from giving antibiotics when calves were making above average gains (2 pounds per day or more for the first 6 months). The Oklahoma station obtained as good results from feeding aureomycin by mouth as when it was administered subcutaneously and better results than when it was given intramuscularly. The Louisiana station obtained

almost the same results. The calves fed aureomycin not only weighed more than the control group, but their frames and skeletal muscles were larger. The Vermont, Pennsylvania, and Iowa stations recommend adding terramycin to the group of antibiotics that stimulate growth in young calves, whereas the last two stations reported that penicillin had no value in this respect.

The question of why antibiotics benefit some calves and not others has not been definitely settled. The Iowa station fed aureomycin to heifer calves from the time they were 4 days of age until they freshened. The maximum growth stimulation occurred before the calves were 6 months old. There was no advantage or disadvantage in feeding antibiotics to older heifers. At levels fed by the Ohio station aureomycin had no effect on digestion as indicated by vitamin synthesis or pH of the rumen fluid up to 6 months of age.

The Michigan station has reported that the vitamin B_{12} requirement of the dairy calf is between 20γ and 40γ per kilogram of dry matter consumed. The Pennsylvania station found no advantage in supplementing the dairy calf ration with vitamin B_{12}. The amount of B_{12} already present in the control ration was not given. According to the Illinois station, more evidence is desired before it can be stated conclusively that vitamin B_{12} is a dietary requirement of the dairy calf.

The New York (Cornell) station sought to determine whether young calves actually needed fat in their diet to survive. Even when calves had been given colostrum for 2 days they died in 1 to 3 weeks when placed on a solvent-extracted "fat-free" milk. Calves at the Kentucky station grew faster when a small amount of Ethomid C/15–16, a surfactant or detergent, was added to the ration. Iowa's experiments with Aerosol C–61 and Louisiana's with Aerosol OS (an anionic compound), Aerosol SE phosphate (a cationic compound), and TEF–16 (a nonionic compound) gave negative results. The idea in feeding detergents was that they would aid in the digestion of the fat in the ration.

Several stations have been comparing the rate of growth of young calves fed filled milk, in which the natural fat has been replaced with fats other than that occuring naturally in milk, with the rate of growth of calves fed whole or skim milk. The Minnesota station showed that calves fed filled milk required more of the B complex vitamins and more tocopherol, vitamin E, than calves fed whole milk. The calves fed filled milk quickly became anemic unless a special mineral supplement was fed. At the Illinois station, calves fed filled milk prepared with a modified lard carefully supplemented with minerals, vitamins, and antibiotics grew as fast as milk-fed calves.

Calves that were given fresh cud inoculations began to eat hay earlier than calves not so inoculated at the Wyoming station, confirming previous research at the Ohio station. Later Ohio findings are that ruman-inoculated calves have a smoother hair coat than uninoculated calves, but inoculations were of little or no help in controlling diarrhea. The inoculation of young calves with the rumen flora of cows increased the apparent digestibility of the protein in their ration from 58.1 to 66.4 percent. At the West Virginia station bacteria counts in inoculated calves were approximately 55 billion per gram at 1 week of age, and increased to 103 billion per gram at 16 weeks of age. At 4 to 5 weeks of age the numbers of bacteria tem-

porarily tended to decrease or remain static as the numbers of protozoa began to build up.

In studies at the Texas station Jersey calves were able to eat considerably more cottonseed meal that is high in gossypol than Holstein calves of the same age. The Idaho station reports that where good quality hay is available dehydrated alfalfa in the calf meal is of doubtful value. This was confirmed in similar research at the Illinois station.

Several stations have been cooperating with the Department to determine the productive capacity of a cow by measuring the size of her udder while she is still a calf. Although results to date are inconclusive, results at the New York (Cornell) station indicate that both nutrition and inheritance affect the size of the developing glands.

Bulls

With natural breeding, one sire is rarely bred to more than 30 cows, and in small herds the bull frequently serves only 5 to 10 animals a year. In 1952 the average number of cows served by one sire in an artificial breeding association was 1,848. This means that bulls used in artificial breeding associations have 60 to 100 times greater opportunity of transmitting their genetic characteristics than the average herd sire.

The Oregon station, studying the carotene and vitamin A requirements of dairy animals for three generations, found that bulls usually breed regularly during their first year of service, even on as low carotene intakes as 50 micrograms per kilogram of body weight daily. After 2 years of age their breeding efficiency decreased. The Louisiana station found pasture grasses and legumes ideal feeds for dairy bulls used in artificial breeding. Regular exercise of bulls at the Vermont station had little influence on their sperm quality. The Minnesota station established that at least four ejaculates can be taken from a bull per week for an extended period of time without affecting the quality or quantity of semen produced.

Several stations including those in Mississippi, Pennsylvania, New Jersey, New Hampshire, and Wisconsin have further experimented with milk as a semen diluter in place of the rather standard egg yolk-citrate mixture. In Pennsylvania and New Hampshire boiled homogenized whole milk or boiled pasteurized skim milk proved to be satisfactory diluters for semen but results with reconstituted skim milk were varied. The Mississippi station had good success with homogenized milk but not with evaporated milk.

The use of valuable bulls would be greatly increased if semen could be shipped long distances or held for considerable periods in a frozen state without loss of potency. In recent years research on safe methods of freezing semen was reported from the British Isles. The Illinois, Arkansas, New York (Cornell), Minnesota, Nebraska, and New Jersey stations are among the first in this country to report successful freezing of bull semen.

The Colorado station has made a careful study of semen characteristics most closely associated with viability and high breeding efficiency. The fructolysis index proved to be the most accurate and simple method for determining these characteristics. The free amino acids in the seminal fluid, it was revealed, indicate gonadotropic activ-

ity. At the Louisiana station the fructose content of the semen was found to vary with the sexual excitement of the bull and the number of spermatozoa per milliliter. The station established that bulls may be expected to produce the highest quality of semen in the winter and spring and the poorest quality during the summer and fall—following several weeks of hot weather.

Scientists at the Ohio station carefully measured the effect of castration on skeletal growth. They found that steers weighed less and had a smaller heart girth than their identical uncastrated male twin, but that both animals were about the same height at withers.

Digestion

A number of State experiment stations are making investigations of the role of bacteria in the rumen. The Maryland station found that the chief end product in the digestion of fermentable carbohydrate material, except succinate and maltose, is acetic acid. With succinate and maltose the chief end product was propionic acid. Fatty acids, if metabolized, yielded only acetic acid. This finding is of special interest when coupled with a previous one. In 1949 the Wisconsin station, after trials in which the fat test of experimental animals had dropped below normal, observed that when acetic acid was given by stomach tube, the fat test returned toward normal, whereas propionic acid seemed to have no effect.

The Michigan station found from in vitro trials that penicillin in the concentrations used (up to 15 units per milliliter) stimulated bacteria which attack fiber (cellulolytic organisms). The station also was able to show that rumen micro-organisms can utilize urea nitrogen to synthesize amino acids. The Illinois station observed that the particle size of the cellulose substrate had little or no influence on rate of digestion. Several cultures of rumen streptococci were isolated which actively hydrolyze starch, principally into lactic acid.

Nutrition

In testing the nutritive quality of some new feeds on the market, the Pennsylvania station found that dicyanodiamide, a nitrogen-containing industrial product, was satisfactory as a partial supplement for protein in dairy heifer rations. The New Jersey station added molasses in a dry form to dairy rations. No difference in growth response was noted when the dried molasses was fed in amounts up to 22 percent of the ration. Recent research has indicated that ground corncobs improve certain beef rations. However, dairy cattle rations containing corncobs always gave poorer results than standard dairy rations at the Indiana station. Similar trials at the Virginia station were inconclusive.

The feeding of minerals in excessive amounts may not only be wasteful but may have an adverse effect on the cow. The New Hampshire station reports that the feeding of 100 grams of limestone daily to a cow caused a significant depression in the digestibility of the protein in her feed. When the land on which timothy and bromegrass was grown had been heavily fertilized, the forage was low in cobalt, iron, and copper, and fairly low in manganese. Under the same conditions ladino clover was low in iron and manganese. There was

no indication at the time the New Hampshire report was made that the low level of trace minerals (cobalt, iron, copper, and manganese) in the feed had any adverse effect on the reproductive performance of the cows studied.

The Michigan station has analyzed several sets of data to learn what amount of grain will yield the highest net return per animal when fed to dairy cattle. The analyses showed that cows producing 11,000 to 12,000 pounds of milk per year can profitably be fed up to 2,500 pounds of grain, whereas those producing about 7,000 pounds of milk should be limited to 1,100 to 1,200 pounds of grain. The recommendations will vary with the quality of roughage, cost of feed, and price of milk.

Potato starch plant waste, a byproduct of potato starch manufacture which is costly to dispose of, can be processed into a satisfactory constituent for mixed dairy feeds. Research at the Maine station shows that the waste, largely potato pulp, can be used at the 20-percent level in mixed feeds. It is very palatable to dairy cattle, equals 90 percent of the feeding value of corn, and is high in nitrogen-free extract although low in protein.

POULTRY RESEARCH

In the past 30 years egg production per hen has increased from an average of 110 to about 180 eggs per year. Similar efficiencies have been brought about in production of poultry for meat. The total progress reflects an intensive program of research in which the industry has given the experiment stations and the United States Department of Agriculture wholehearted, enthusiastic support. Each year sees many new innovations in poultry breeding, feeding, and management. Some of the examples of recent progress are here presented.

Breeding for Profit

Use of X-ray in breeding

A completely new experimental approach to breeding for high egg production is under way at the California station. Normally, in prolonged breeding programs, the qualities for which selections are made increase up to a point, after which, in many instances, the rate of improvement levels off. In order to break through the leveling-off period and to obtain additional gains, the California station is using X-ray treatments to produce mutations in the chromosomes of chickens.

Through 19 years of intensive breeding, the main flock at the station has reached a high level of egg production. X-ray-bombarded semen is now being injected into the hens by artificial insemination. This treatment will be given through five generations. Inasmuch as the mutations produced are permanent, the average number of mutations per bird will increase throughout the period. In each generation, the genes and chromosomes from different individuals will be mixed and recombined. By means of this reshuffling, it should be possible to retain the useful mutations and discard the bad ones.

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New breeds for high altitudes

One of two new breeds of chickens being developed at the Wyoming station for use at high altitudes is of dominant white color, of medium weight and growth rate, and lays brown eggs. It is outstanding in ability to lay large numbers of eggs. When crossed with any other breed, its offspring are always white in color. The other breed is of light red color, similar to that of the New Hampshire, and has a very rapid growth rate, and outstanding body conformation for meat production. When these two breeds are crossed, the white crossbred offspring lay as well as the dominant white parent, their eggs hatch better than those of either parent breed, and they have a growth rate better than the average of the parent breeds.

Effect of inbreeding on reproduction

As hybridization becomes more widespread in the poultry industry, the consequences of inbreeding in poultry assume greater importance. The Storrs (Connecticut) station in 1923 and the Massachusetts station in 1924 and 1934 reported investigations on the response of poultry to inbreeding. The results proved that inbreeding has a depressing effect, although different characters did not respond to the same degree. The Minnesota station in 1948 first demonstrated the effect of inbreeding in poultry on the performance of specific characters by computing the regression of performance of various characters on the degree of inbreeding. An increase in inbreeding resulted in a considerable decrease in hatchability and egg production of about equal proportion, and its effect on sexual maturity was intermediate, but there was no significant change in body weight and egg weight. At the same time the Iowa station reported that there was a decline in egg production rate of 1.4 percent for each percentage increase in inbreeding.

Last year the Iowa station studied the effect of inbreeding on egg production rate, using the records of 9,999 White Leghorns over a 14-year period. The birds were classified into 23 inbred and 3 "non-inbred" lines. Full-sib (sister-brother) and half-sib matings had been generally practiced, and the inbreeding coefficients ranged from 0 to 85 percent. Differences in egg production among the inbred lines were significant. Thus inbreeding appears to be a much stronger force than selection in influencing egg production.

The North Carolina station made a similar study on data collected over a 6-year period from 3,583 pullets of 482 dams and 64 sires, representing one inbred line of White Leghorns and two inbred lines of New Hampshires. There was very little crossing between the progeny of different sires within lines, which resulted in a steady increase in the average degree of inbreeding from 8 percent in 1946 to 52 percent in 1952. The results indicate that there was no significant change in performance for egg weight and body weight at sexual maturity, with an increase in the coefficient of inbreeding. Egg production, age at sexual maturity, and hatchability of fertile eggs did show a significant change as inbreeding progressed. The effect of inbreeding was to decrease the egg production during the first 6 months, increase the number of days to sexual maturity, and decrease the hatchability of fertile eggs.

Inheritance of fertility

Low fertility in certain inbred lines of chickens and some families of White Holland turkeys is being investigated by the Pennsylvania station. In chickens, representatives of three inbred lines and of one cross between inbred lines were tested for the duration of fertility following a single insemination with 1/20 cc. of semen from each of three inbred males and one outbred male. Duration of fertility was shorter for "within-family" matings than for "cross-family" matings. Fertility duration was longer for matings with the outbred male than with inbred males for each group of females. It is evident that the ability of chicken females to retain functional semen is influenced by the degree of inbreeding; also, that the semen produced by inbred males gives a shorter duration of fertility than that produced by outbred males.

In turkeys, 17 full-sister families were tested for duration of fertility following a single insemination with 1/20 cc. of pooled semen obtained from 9 males. The duration of fertility in full-sister groups varied from 25 to 50 days, whereas, in individual females it ranged from 10 to 53 days. This preliminary study provides additional evidence to support the theory that fertility in turkeys is inherited on a genetic basis.

The influence of genetics on hatchability

Eight years ago the Massachusetts station initiated research to develop a high and a low hatchability line by means of selective breeding, through the use as foundation stock of yearling female breeders that had been tested for hatchability the previous year. The mean hatchability of the hens used to start the high line was 92.5 percent, compared with a mean of 45.1 percent for the breeders in the low line. Matings in 1945 showed a mean for the high line of 78.2 percent and 68.7 percent for the low line.

Pedigree selection breeding has been carried on within each line through eight generations. Mean hatchability fluctuated from generation to generation with the average in the two lines showing significant differences. In 1951, the hatchability was 86 percent for the high line and 68 percent for the low line; in 1952, it was 71 percent and 61 percent, respectively; and in 1953, 94 percent and 74 percent, respectively. Fertility has been satisfactory in all generations. Rather striking is the fact that low viability is a characteristic that appears in the embryos and in the birds of all ages in the low line.

Advancements in Nutrition

Methionine—an important nutrient

The amino acid requirements for growing chicks were reported in 1952. Additional information on the need of poultry for methionine, the first of the essential amino acids to find practical application in avian nutrition, is now available. At the Texas station, levels of methionine, varying from as little as ½ pound per ton of finished broiler feed to as much as 5 pounds of feed-grade methionine per ton, were compared. One-half pound to 1 pound per ton produced the best and most consistent results. A significant increase in the growth

of broilers, ranging from 3 to 10 percent in some experiments, was obtained. The best growth occurred when the methionine was fed in the presence of fishmeal or fish solubles. Inasmuch as both fishmeal and fish solubles contain considerable methionine, apparently the free amino acid is needed for some particular reaction inside the body of the bird. The feather score of New Hampshire chicks given feed-grade methionine under field conditions, was improved approximately 25 percent by the addition of 1 pound of the amino acid per ton of feed.

In a 10-week broiler trial at the Maryland station, the addition of 0.05 percent DL-methionine (synthetic dextro-levo-methionine) to the ration increased the return over feed cost by $26.88 per 1,000 broilers marketed, estimating broilers at 27 cents per pound, basal ration at 5 cents per pound, and DL-methionine at $3 per pound.

Research with turkeys at the Texas and Utah stations has resulted in better feathering, increased growth, and high efficiency of feed utilization through the supplementation of the feed with methionine. In fact, at the Texas station, the addition of 1 pound of methionine to a ton of an all-vegetable-protein ration, adequate in vitamins, minerals, and amino acids to meet the poults' requirements, gave 10 to 34 percent increases in weight. Moreover, a growth response of from 8 to 14 percent occurred on such a ration supplemented with both an antibiotic and methionine above that on the ration with only the antibiotic added. At the Nebraska station, on the other hand, the addition of 0.5 percent of feed-grade DL-methionine to a basal feed mixture containing meat scraps, fishmeal, and soybean meal, gave no significant improvement in the rate of growth of poults, but did improve the efficiency of feed utilization.

Tolerance to brackish water

At the present time, little use is made of land in Hawaii where the salinity of the water is high. Therefore, the Hawaii station has conducted experiments to determine the tolerance of New Hampshire cockerels and pullets from 6 to 12 weeks of age to various concentrations of brackish water ranging from only 4.4 grains of salt per gallon (tap water) to as high as 400 grains per gallon. The standard ration fed contained 0.5 percent of salt (NaCl). The production of the hens at 27 weeks of age ranged from 61.3 percent on the 4.4 grains per gallon to 69.2 percent on the 400 grains per gallon. There was no adverse effect on feed consumption, body weight, or survival. A marked increase in consumption of brackish water by both males and females occurred as the salt concentration increased. However, the salt content of the brackish water consumed by the pullets biweekly, when expressed as the percentage of feed consumed, did not exceed 2.9 percent of the diet during any period of measurement. These results indicate that chickens can be raised safely anywhere in the Hawaiian Islands. Thus, it will be possible for commercial poultrymen to move to areas where water is brackish (up to 100 grains of salt per gallon of water) when their leases expire.

The prevention of encephalomalacia

Nutritional encephalomalacia, or "crazy chick" disorder, was first noticed in the late 1920's at the Indiana station when 3 percent of cod-

liver oil in the diet of growing chicks produced a severe disturbance of the nervous system in some of them. Subsequent research at the New York (Cornell) and Storrs (Connecticut) stations, as well as by the Department, showed that natural and synthetic alpha-tocopherol (vitamin E) prevents the development of nutritional encephalomalacia when fed simultaneously with, but independently of, a high-fat ration. In recent work by the Storrs station (Connecticut), a high incidence of encephalomalacia was produced in chicks that were hatched from hens deficient in vitamin E, and were raised on a low vitamin E diet containing 2 percent of "vitamins A and D feeding oil."

Remarkable protection against this disorder was obtained by feeding diphenyl-para-phenylenediamine, an antioxidant used to protect carotene in feeds. The mortality of chicks fed the basal diet containing 2 percent oil without the antioxidant was 59 percent, whereas chicks fed the antioxidant showed very low mortality. The fact that diphenyl-para-phenylenediamine is not absorbed from the intestine indicates that the causative agent of encephalomalacia arises either in the feed or in the intestinal tract in the absence of an antioxidant and that the absorption of the antioxidant into the tissues is unnecessary for protection of the chick.

The role of antibiotics in nutrition

Since bacterial contamination of the environment was considered likely to influence the action of antibiotics in stimulating growth in chicks, studies have been carried out at the Maryland and Texas stations, and by the Department, to compare results in a clean and a normal environment. Chicks reared at the Maryland station in a new room containing new equipment grew more rapidly than chicks reared under the usual environment for battery brooder-reared chicks. This was true regardless of the type of ration used. The addition of penicillin did not appreciably improve the growth of chicks reared in the very clean environment, whereas a growth response was observed in the normal environment.

Previous work by the Maryland station has shown that antibiotics increase the number of coliform bacteria and reduce the numbers of lactobacilli in the chick cecum. Accordingly, chicks were fed massive cultures of these coliform organisms to determine their influence on growth. Slight but consistent increases in growth over controls were noted when these cultures were fed. At the Texas station it was found than antibiotics produce a significant decrease in anaerobic (clostridia) bacteria in fecal material and that such decreases can be associated with increases in chick growth. The results suggest that chick growth is influenced by the types and numbers of micro-organisms present in the intestinal tract of the chick.

New and unidentified factors

In the face of the newer knowledge of nutrition which has revealed a multitude of factors—vitamins, amino acids, minerals, hormones, fatty acids—involved in proper nutrition, there are still many unknown nutrients that challenge the research worker. Among the stations that have accepted the challenge are Idaho, Iowa, Maryland, Minnesota, New York (Cornell), Texas, Washington, and Wisconsin.

According to experimental results obtained at the Arizona and

Illinois stations, dehydrated alfalfa contains one or more unidentified factors which stimulate the growth of chicks. They appear to be distinct from the liver or whey factors. At the Arizona station the effect of these factors was enhanced by feeding the chicks a vitamin-A-deficient diet, previous to placing them on experiment. Brewer's yeast and sardine meal contain factors which produce the same growth stimulation. The amount of unidentified factors stored in 1- to 3-day-old chicks varied with the hatch. The amount of casein in the diet did not affect significantly the growth-stimulating property of alfalfa.

A factor that improves feather pigmentation, growth rate, feed efficiency, and calcium deposition in the skeleton is supplied in large quantities by soybean oil meal, and casein, according to the Tennessee station, but is scarce in peanut meal, sesame meal, and meat scraps. The Colorado station has found that the addition of liquid betaine concentrate to a nutrient-complete, all-plant-protein diet will increase the growth of chicks. At the Utah station, a combination of histamine and an antibiotic increased the growth rate significantly more than the antiobiotic alone.

Value of surfactants in doubt

About two years ago a report was published to the effect that certain "surface active agents," including many commercial preparations for home laundry and dishwashing use, have a stimulating effect on growth rate when fed to chicks. In order to confirm this report, the Washington station added a number of detergents (surfactants) and germicides at various levels to a chick basal diet. Either procaine or diamine penicillin was used as a positive control to obtain comparative effects of the supplements on growth. In all feeding trials, penicillin alone produced a significant growth response. The detergents and germicides either produced no significant growth response or, in some cases when fed at high levels, depressed growth.

In the Illinois station's research with surfactants it was found that when an all-plant diet, to which crystalline B_{12}, niacin, choline, riboflavin, and pantothenic acid had been added, was supplemented with any one of a number of surface-active agents, chick growth was not improved at 4 weeks. One of the surfactants (Ethomid C/15) was fed for a period of 10 weeks without significantly improving growth. The station concluded that no advantage resulted from adding the surfactant to the diet containing vitamin B_{12} and aureomycin.

At the Maryland station, on the other hand, although no increased growth responses were noticed for the first 5 weeks in chicks fed two surfactants, growth had apparently been stimulated by the end of the seventh and eighth weeks, to the same degree as by penicillin by a combination of the two surfactants. Combinations of the surface-acting agents and penicillin, however, were no more effective than either supplement fed singly.

New high efficiency ration for hens

As a result of 2 years of research by the Storrs station (Connecticut), a high efficiency ration for laying hens has been developed. Paralleling in importance the high efficiency broiler ration developed at Storrs in 1947, the new laying ration produces more eggs and greater

gains in body weight from less feed than standard rations. The net cost of producing a dozen eggs is considerably less. In the new ration, yellow corn and 20 grams of niacin per ton replace the ground oats and one-half of the standard wheat middlings previously used. Official tests have shown this new ration to be especially good for use in laying pens equipped with automatic feeders. Litter in pens using this high corn feed is drier than in pens fed standard rations, which indicates that the birds fed the corn ration secrete less water. The new feed is slightly more expensive per ton than the standard ration. However, this small extra cost is more than offset by the efficiency of the high energy ration.

Wood waste for poultry

A waste product from Wisconsin's large paper industry may prove to be a valuable poultry feed, according to the Wisconsin station. The product, called torula yeast, is produced from the liquid drawn off after wood pulp is treated with sulfite. The yeast contains about 45 percent protein and some valuable vitamins and unidentified factors. An all-vegetable ration with 20 percent torula yeast replacing a part of the soybean oil meal produces good growth in poultry. Untreated sulfite wastes are one cause of pollution in our lakes and streams. The yeast treatment of this waste may give the poultry industry a valuable new protein feed to meet some of the increasing shortages of feed protein.

Research on Egg Quality

Nutritional loss in storage

Interior quality of shell eggs changes during storage of the eggs. Certain chemical changes also occur, such as a transfer of water and some nutrients between the yolk and the white. The Michigan station has found that eggs stored for 12 months decrease in niacin, pyridoxine, riboflavin, pantothenic acid, and pteroylglutamic acid (folic acid) content, but not in either choline or biotin. Eggs lost 16 percent of their folic acid during 6 months of cold storage and 27 percent during 12 months of cold storage.

Preserving quality with CO_2

The Minnesota station has tested the value and practicability of using CO_2 (carbon dioxide) as an aid in preserving the quality of cartoned eggs as they pass through normal market channels. A comparison was made of oiled eggs, eggs over-wrapped snugly in a plastic-type bag on the outside of each carton, and eggs in a plastic bag with a pellet of solid CO_2 included. The use of the moisture-vapor-proof carton without added CO_2 was about as efficient as oiling in preserving quality, particularly when the eggs were packaged within 24 hours after laying. The advantage of adding CO_2 became greater as the interval between laying and packaging increased. This can probably be explained on the basis that fresh eggs liberate excess CO_2. If this escaping gas can be trapped within the package so that an equilibrium is reached in a short time, the albumen can be stabilized. In commercial practice, however, the time lapse between laying and cartoning is sufficiently great to allow the escape of considerable CO_2.

Meat Investigations

Estrogenic treatment

Use of the synthetic estrogenic compound diethylstilbestrol for fattening cockerels has gained considerable popularity among poultry producers. Because this compound produces female sex hormone activity in man, it seemed desirable to the Ohio station to determine, if possible, the amount of the hormone that is carried over in the meat of cockerels treated with this substance. No significant amounts were detected in either the livers or breast muscle and abdominal fat of chickens receiving 15 milligrams of diethylstilbestrol by fat-type pellet and chickens receiving 15 milligrams of aqueous pasty-suspension through subcutaneous injections in the neck at the base of the head. The pellet residues in the necks of the chickens averaged 3,970 micrograms of diethylstilbestrol, whereas the residue from the aqueous-type preparation averaged approximately 280 micrograms, half of the birds having no detectable amounts present. These results indicate that hormone implants should be placed in the bird in such a way that upon dressing the carcass the site of implantation will be discarded and not reach the consumer in order to avoid the possibility of an adverse effect.

Poultry Physiology

Ovulation in nonlayers

Ovulation and the subsequent laying of a normal egg, usually within 26 hours, are preceded and accompanied by certain changes in the body of the hen. Some birds behave as though they were laying and show appropriate changes in body condition without actually producing an egg. The New York (Cornell) station, upon dissecting more than 200 mature but nonlaying Leghorns, found that a majority possessed normal, fully developed, and apparently functioning reproductive systems. No obvious cause for the failure of these birds to produce eggs was recognized, although there was some evidence that genetic factors were involved. In some other cases, a faulty development of the oviduct made egg formation impossible. Nevertheless, the birds were ovulating and nesting. Obviously, it is impossible to identify all nonlayers by physical inspection. Neither is it correct to assume that normal-appearing, trap-nested birds without egg records are laying on the floor.

Temperature effect on egg size

In 1950 the Kansas station reported that egg size was depressed by temperature in the hotter summers. If the hens were not subjected to high summer temperatures, egg size increased throughout the entire first laying year. It also concluded that a constant temperature of 65° F. is too high for maximum egg size.

Recent research on the same subject by the Puerto Rico station appears to agree with these findings. The warmer temperature in Puerto Rico as compared with that of the United States causes the egg size to increase more slowly at the beginning of the laying year, reaching a maximum from May to June, but with the higher summer temperature, egg size decreases faster toward the end of the laying

year. The egg size of the New Hampshire and the White Leghorn breeds was smaller than is commonly seen in similar flocks on the mainland. It is not clear, however, whether this smaller egg size is a result of a depressive effect of high temperature or is attributable to the breeding of the birds.

Rapidity of digestion

In studies at the California station, it was found that food passed through the alimentary canal of laying turkey hens in 3 hours and 13 minutes and through nonlayers in 4 hours and 16 minutes. Young turkey hens required 2 hours and 27 minutes for food passage compared with 3 hours and 52 minutes for old turkey hens. Thus age was a more important factor than production. Laying chickens required 3 hours and 42 minutes, and nonlaying chickens 3 hours and 50 minutes. Penicillin in the feed slowed the rate in turkeys and chickens of both sexes, 4 months to 2 years of age, to the extent that the antibiotic-fed birds averaged 3 hours and 15 minutes, whereas the birds on normal mash averaged 2 hours and 57 minutes for food passage. Environmental temperatures of 60° and 90° F. caused very little difference in the time that the food remained in the digestive tract.

SOIL SCIENCE AND PLANT NUTRITION

Knowledge of certain chemical elements required by plants only in trace amounts, has expanded quite rapidly in recent years. These elements are usually referred to as trace, micro, or minor nutrients, and include boron, copper, iron, manganese, zinc, and molybdenum. In terms of animal requirements, cobalt and iodine are also known as trace or minor nutrients. Research with the former group of trace elements has been selected for presentation in this report as an illustration of the progress being made in soil science and plant nutrition.

Soil Studies With Trace Elements

Trace element deficiencies in the soil may result from an insufficient supply of these elements, removal in crops, fixation in the soil, or leaching. Since soluble compounds, used in fertilization as sources of the trace elements, may be leached out of the soil, or become fixed in an unavailable form, the use of insoluble sources has been tried. Such sources, in addition to preventing leaching and fixation losses, eliminate the possibility of harmful plant effects due to overapplications of soluble materials.

Minor element sources

An insoluble source which now looks quite promising is known as "fritted trace elements" (FTE), in which the various elements are embodied in a glass matrix. This material releases its nutrient elements slowly in the soil in sufficient quantity to meet plant needs. Significant crop responses to applications of FTE have been reported by the Ohio, South Carolina, Michigan, Virginia, and other stations. In none of these experiments were deficiency syptoms evident in the untreated plots, indicating that plants may respond to trace elements

even though the soil supply is adequate to prevent outward deficiency symptoms.

In a study of sources of boron at the Alabama station, colemanite was found to be only 19 percent, and howlite 4 percent as soluble as fertilizer borate. Both colemanite and howlite were found to be good sources of boron for turnips and soybeans. Boron increased crimson clover seed yields 3- to 6-fold at four different locations. Hot water extractable boron correlated well with the seed yields of crimson clover.

In similar studies, the South Carolina station found colemanite to be less toxic to seedlings than the more commonly used borax and fertilizer borate, especially on sandy soils. The accumulations of boron in soils as a result of three annual applications of colemanite was no greater than from the application of equivalent rates of borax or fertilizer borate, and the colemanite proved to be a good source of boron. In these same experiments, however, two fritted sources of boron (one a boron frit and the other a trace element frit) produced higher yields of soybeans than either colemanite or howlite. A close correlation existed between the amount of boron applied in FTE, or other source, and that found in the resulting plants. On the other hand, no such correlation existed for manganese.

Effect of location and soil treatment

The Storrs station (Connecticut) found that alfalfa grown in the Connecticut Valley was higher in molybdenum than that grown on soils in the eastern highland area of the State. Soils in the latter area, when treated with molybdenum, produced alfalfa containing 13 p. p. m. of the element, or enough to be potentially dangerous from the standpoint of being toxic to animals. On another crop, lettuce, typical molybdenum deficiency systems developed on unlimed soils, as well as at low rates of liming. On heavily limed soils no response was obtained to molybdenum additions.

Liming soils was found to depress the uptake of cobalt and manganese by the New Hampshire station. The addition of trace elements to soils did not always result in increased amounts in the crops produced. Cobalt showed the greatest increase. Zinc increased slightly, whereas manganese, copper, and iron showed little change due to soil applications. The leaves of red clover were higher in trace elements than the stems, although the blossoms contained more cobalt than the leaves but less copper, manganese, and iron. Ladino clover, timothy, and bromegrass grown under conditions of heavy fertilization (for production of maximum yields) were found to contain levels of cobalt, copper, and iron insufficient to maintain milk production and growth rate of dairy heifers.

The Massachusetts station found that rates of 12 and 24 pounds of boron per acre, when used for the second consecutive year, caused toxicity to the leaves of both legumes and grasses on Merrimac fine sandy loam. Different rates of lime, from 2 to 16 tons per acre, had no effect on the boron content of legumes. In 1950 smooth bromegrass ranged from 45 to 120 p. p. m. of boron, but contained only 8 to 12 p. p. m. in 1952, two years after the boron had been applied. Alfalfa also was lower in boron in 1952 than in 1950. This difference in plant composition reflected the change that had occurred in the soil boron.

Slightly over one-fourth of the boron applied at the 12- and 24-pound rates was in the top 8 inches of soil in the fall of 1950, but in 1952 this layer of soil contained only 10 and 15 percent of the respective amounts applied. Where 6 pounds per acre was used, adequate boron for alfalfa remained in the soil after 2 years. Neither orchardgrass nor smooth bromegrass was injured by rates of boron normally applied for legumes.

Amounts of trace elements in soils

The South Carolina station found wide differences between the cobalt content of soils. Piedmont soils derived from basic diorite and basalt rocks ranged from 54 to 135 p. p. m. of total cobalt, whereas those from acid igneous rocks such as granite, gneiss, and shist contained only 1.5 to 3.25 p. p. m. Soils derived from mixed basic and igneous parent materials were intermediate, ranging from 4.7 to 24 p. p. m. of cobalt.

In contrast to the soils of the Piedmont Plateau, the sandy soils of the Coastal Plain contained very small amounts of total cobalt, varying from 0.85 to 1.85 p. p. m. Certain of the lower-lying bottom and terrace soils of the Coastal Plain, however, contained up to 39.5 p. p. m. of cobalt.

The South Carolina findings show that there is much more uniformity in the molybdenum content than in the cobalt content of soils. Soils ranged from 0.65 to 2.42 p. p. m. in molybdenum content, with an average of 1.25.

The Hawaiian station found that the fixation of zinc by soils with high pH does not play a dominant role in causing zinc deficiency. Response to applications of zinc was obtained only on the highly weathered acidic soils (pH 4 to 5) in the moderate and high rainfall areas. Alfalfa and tomato were found to be good indicator plants for studying availability of zinc in soils. Plant analyses were contradictory to the response patterns, however, since plants grown on the acidic soils where response was obtained contained the most zinc.

Manner of handling soil samples

The Iowa station found that the manner of handling soil samples is important because the amount of either water-soluble or exchangeable manganese may be increased by air-drying, heating, or steam sterilization in certain soil types. Both forms of manganese were greatly increased in Marion soil by air-drying, but there was no change in the case of Grundy soil. Ovendrying at 110° C. gave marked increases in both soils, but the effect was greatest in the Marion. There was little added effect in this soil when it was heated to 250°, but a large increase occurred in the Grundy. Steam sterilization resulted in large increases in both forms of manganese in the two soils, regardless of previous treatments such as heating, desiccation, or rewetting. Both water-soluble and exchangeable manganese increased in amounts with steam sterilization up to 9.5 hours. It is believed that the effects of steam sterilization and moisture may be independent, but that when the treatments are combined their effects are additive.

Iron chlorosis

It has long been realized that applications of inorganic iron salts to the soil are not always effective in preventing iron chlorosis of plants. Foliar sprays likewise are sometimes not effective. Although the methods of placing iron salts in holes and of injecting iron solutions into trees have produced satisfactory results, they are not practical for large-scale use. At the Florida station it was found that chelating agents, which form stable complexes with iron, were very effective when applied to the soil. A single application of chelated iron (ferric sodium ethylenediamine tetraacetate, known as EDTA), made during the dormant season, resulted in complete correction of iron chlorosis within 6 weeks. New leaves were green, and appeared 2 or 3 weeks earlier in the spring than on untreated chlorotic trees. Response was obtained from as little as 6 grams of chelated iron applied to the soil around deficient orange trees, and more than twice as much iron was found in the leaves of these trees than in those of untreated ones.

Large soil applications of ferrous sulfate resulted in only slightly more iron in the leaves than where no iron was used. The Florida scientists believe that this is because the iron in inorganic salts, such as ferrous sulfate, is precipitated as the very insoluble hydrated ferric oxide, and thus becomes unavailable to plants. Iron applied in the chelated form is not free to react in the soil, and thus is not rendered unavailable by chemical precipitation but remains in a form which plant roots can utilize.

The North Carolina station found that certain metal ions have the ability to activate the enzyme system which brings about the reduction of nitrates in plants. It was established that this nitrate reductase enzyme (from soybean) can be inactivated by the metal chelating agent EDTA, and then reactivated by certain metal ions. The most effective activators were manganese, iron, zinc, and magnesium, listed in order of decreasing activating ability.

Inorganic iron salts did not give satisfactory control of chlorosis of the ornamental plant *Dracaena sanderiana*, and export of this plant from Puerto Rico was threatened. Experiment station researchers found, however, that good control could be obtained with iron EDTA, either when applied as a foliar spray or when added to the nutrient solution in the greenhouse. Sprayed plants recovered from severe chlorosis in 2 to 3 weeks, but recovery was slower for those receiving the EDTA in the nutrient solution. After 2 months there was no difference between methods of application, and all plants were suitable for export. Plants treated with ferrous sulfate showed improvement but never reached export quality. The new growth from these plants was suitable, however, for export.

Spray applications of iron EDTA at the California station gave good control of iron chlorosis of pears growing on calcareous soils. Both surface and subsurface soil applications of this material, in amounts up to 4 kilograms per tree, have given no response to date under field conditions. It was found also that caution must be exercised when using iron EDTA as a spray on different plants because the range between ineffectiveness and toxicity is quite narrow.

Utah station scientists found that bicarbonate and calcium ions were the only ones present in large quantities in soils where iron

chlorosis is a problem. In solution culture studies calcium caused an increase in iron uptake, whereas bicarbonate decreased iron uptake and caused chlorosis. Plant growth, chlorophyll content of the leaves, and absorption of iron were reduced by low oxygen content and the presence of carbonate ions. At low oxygen pressure, effects of the chloride ion were similar to those induced by the bicarbonate ion, but when ample oxygen was added by aeration of the solution cultures, the bicarbonate ion was much more injurious. Both bean and tomato plants absorbed appreciable amounts of bicarbonate carbon, as determined by the use of radio-carbon.

Plant Studies With Trace Elements

Trace elements appear to function in plants, either directly or indirectly in enzyme systems, or as catalysts in bringing about or speeding up certain physiological processes.

Movement of growth regulators

The Maryland station (coop. USDA) found that there is a striking relationship between boron and the movement of applied plant growth regulators or hormones. Previous studies had shown that boron facilitates the translocation of sugars, and that the movement of plant growth regulators is associated with the movement of sugars. In the Maryland studies, boron was found to have a pronounced effect upon the movement of 2,4–D. The severity of action of this material, when applied to bean leaves, was markedly enhanced by the addition of boron alone, but when sugar also was included the degree of action was much greater. Glucose, or grape sugar, was found to be more effective than either sucrose or fructose for this purpose. This research may lead to the practice of using boron and sugar to enhance the activity of growth-regulating compounds.

Foliar application

Applications of nutrient sprays over a 4-year period were found to be of little or no benefit to crops, in experiments at the Delaware station, especially when used as a supplement to standard soil fertilization. Using a sticker did not increase or prolong the effectiveness of the nutrient sprays. On one crop, potatoes, the yield was reduced by the sticker. Foliar application of trace nutrients, however, offers possibilities in instances where soil fixation, leaching, and unfavorable moisture, or pH may limit normal root feeding. In addition, where pesticide sprays are used at regular intervals, trace or other nutrient elements may be included at little extra cost.

Leaf samples from 44 untreated peach orchards in North Carolina had an average content of 12 p. p. m. of zinc. The station found that where zinc was applied as a foliar spray, the zinc content of leaves was increased 4- to 6-fold. Zinc deficiency symptoms were evident in 8 out of 9 orchards where the leaves contained less than 8 p. p. m. of the element. Foliar sprays in May and June were much more effective than dormant sprays or soil applications in correcting zinc deficiency, even though much less zinc was applied. Both of the latter methods, however, produced some benefit the following season.

Organic acids and enzyme systems

The effect of different levels of iron and manganese on the amount of organic acids and the level of enzyme activity in plant tissues was studied at the New Jersey station. Low iron and high manganese nutrition resulted in a greater quantity of organic acids than high iron and low manganese, in the leaves of Havana seed tobacco. Maleic acid constituted the major single organic acid present. Iron-deficient chlorotic sunflower leaves were much lower in catalase and peroxidase activities than plants grown with an adequate supply of iron. High manganese had the same effect as low iron in inducing typical chlorosis and reducing the activity of these enzymes. Intermediate levels of both iron and manganese produced normal plants.

The New Jersey station also reported that a decrease in the nutrient level of boron caused an increase in total organic acids in tomatoes. Catalase activity of boron-deficient tomatoes exceeded that of plants grown with sufficient boron. Present indications are that boron-deficient tomato tissues respire more rapidly than normal tissues. Cell necrosis in boron-deficient tomato plants occurred first in the outer basal portions of the youngest undeveloped leaves, next in the inner portions of these same leaves near the junction of the base and the dome of the meristematic tissue, and finally in the vacuolated cells beneath the meristematic region across the whole of the young shoot apex.

Composition of legumes and grasses

Manganese-deficient alfalfa was found by the Indiana station to contain more nitrogen than normal alfalfa. The greatest difference occurred in the amide, free amino acid, and nitrate nitrogen fractions, in which deficient plants were considerably higher than the nondeficient. The latter, or normal plants, were slightly lower in protein than the former.

Plant analyses conducted at the Virginia station (coop. USDA) showed that ladino clover is higher in boron, cobalt, copper, and zinc content than orchardgrass. Out of 80 grass samples collected in the southern Coastal Plains area, more than one-half was deficient in cobalt (0.05 p. p. m. or less) from the standpoint of animal nutrition, whereas more than one-third of these from the northern section of the Coastal Plains was deficient. Copper was also found to be deficient (6.50 p. p. m. or less) in grass grown in the Coastal Plains soils. In the northern part of the area about one-third of the samples were deficient, and in the southern part almost one-half were too low in copper for adequate animal nutrition. Orchardgrass was higher in molybdenum and manganese than ladino clover. With the exception of zinc, the average plant content of these elements was higher in the samples from the northern than those from the southern Coastal Plains.

The Missouri station continued its investigations of the functioning of trace elements as catalysts in protein synthesis. From the standpoint of animal nutrition the amino acid composition of protein was improved by the addition of trace elements to the soil. Breeding troubles and Brucellosis infection in dairy animals were reduced by feeding grain from soils treated with trace elements.

Miscellaneous findings

Although nickel has not been established as being necessary for plant growth, several instances of response to nickel have been reported. The importance of this element at present, however, lies more in the possibility that it may have toxic effects on certain soils. The Hawaiian station found that the 10 Great Soil Groups in the Islands ranged in total nickel content from 98 to 661 p. p. m., whereas exchangeable nickel ranged from 0.31 to 2.56 p. p. m. Plants varied from 0.83 to 22.8 p. p. m. in nickel content, most of them falling between 2 and 5 p. p. m. Tomatoes in nutrient solution developed toxic symptoms with 1.0 p. p. m. or more of nickel. Plants injured by excess nickel contained over 50 p. p. m. of the element. Toxic effects were also obtained by adding nickel to soils to get amounts ranging from 400 to over 800 p. p. m. The addition of lime to these soils counteracted the toxic effect of the added nickel, and reduced the amount of the element taken up by plants.

Studies by the New Jersey station revealed that soils in that State contained from 8 to 22 p. p. m. of nickel. Plant starvation symptoms induced by a deficient supply of copper, manganese, zinc, or iron, could not be corrected by nickel, nor could this element be established as necessary for normal plant growth. The severity of nickel toxicity in tomatoes could be reduced by adding 1 p. p. m of iron, but a like amount of copper or manganese or 5 p. p. m of iron had no effect. Crops grown on Coastal Plain soils contained more nickel and copper than those grown on Appalachian soils. Ragweed and red clover accumulated nickel.

In other trace element research, the New Jersey station found that soils contained from 0.2 to 30.8 p. p. m., and crops from 0.01 to 0.32 p. p. m. of cobalt. It was not established that this element is necessary for plant growth. Cobalt toxicity in alfalfa was partially overcome by either molybdenum or manganese. Molybdenum deficiency in alfalfa was overcome by 1 pound of sodium molybdate per acre, which increased yield from 3 to 6 percent. Many soils in the southern part of the State were low in exchangeable and easily reducible manganese, but normal plant growth was obtained by applying 50 pounds of manganese sulfate per acre. On overlimed soils, manganese deficiency was corrected by spraying the plants, or by additions to the soil. Manganese was found to move upward only in plants, so that spraying of the lower leaves was required to correct the deficiency.

In studies with the peanut plant at the North Carolina station, it was found that boron had a striking effect upon fruiting. A deficiency of boron markedly reduced the number of flowers. Although the deficient plants produced just as many reproductive nodes as the nondeficient, they produced no pegs whatsoever.

New scientific methods

Techniques were developed at the California station for employing algae in micro-nutrient research in place of higher plants. Deficiencies of molybdenum, manganese, and iron were produced in *Chlorella pyrenoidosa* grown in a nutrient solution under artificial light. Exposure of algae to radioactive carbon dioxide offers a means of studying how trace elements function in green plants, and how their deficiencies

affect the process of photosynthesis. Molybdenum-deficient algae were found to have, per unit of dry weight, a lower rate of photosynthesis and a higher rate of respiration, than normal cells. The use of algae for such studies offers the advantages of ease of manipulation, economy of time, and in having physiologically reproducible experimental material readily available.

FORAGE CROPS, PASTURES, AND RANGES

Well-balanced rations are necessary to insure good animal nutrition and health. Roughage and forage crops have been receiving greater attention as sources of vitamins and minerals and also as economical and efficient carriers of major nutrients. Good management practices are essential in producing such crops. Improved varieties should be used, adequate fertilization should be provided, efficient harvesting and preservation measures should be followed, and improved methods of utilization should be developed. Much of the progress in livestock production in recent years has been brought about by growing improved forage crops, pastures, and ranges. Research along these lines, carried on by State agricultural experiment stations, much of it in cooperation with the U. S. Department of Agriculture, has resulted in efficient production of meat and milk, increased the carrying capacity of cropland, increased soil fertility, and improved soil conditions on many farms.

Feed Processing and Preservation

With the advent of grass and legume silage much research was needed on methods of producing feeds high in nutritive value, ways to prevent waste and spoilage, and ways to improve the palatability of preserved forage crops. At the same time better methods of producing a higher quality dry hay have been devised and haymaking procedures have been improved through proper harvesting, the use of more efficent machinery, and the speeding up of the curing process with hay driers and preservatives.

As a result of 17 years' work and the examination of hundreds of samples of silage, the Massachusetts station reports that the use of preservatives for grass silage depends to a large extent on the water content of the ensiled crop. Good silage can be made without a preservative if the water content of the grass is in the range of 60 to 70 percent. If the moisture content is above 70 percent the crop should be wilted or a preservative or conditioner added. The best way to condition silage is to add 150 pounds of hominy or cornmeal per ton of green crop. Sulfur dioxide preserves nutrients very well but it is hard to apply and silage conditioned with this preservative is not as palatable as that conditioned with meal.

The Illinois station found that ground ear corn is superior to corn-sugar molasses as a conditioner for high-moisture alfalfa-bromegrass silage. Less seepage occurred from the silo when this conditioner was added, and dairy heifers consumed more dry matter and made greater daily gains on the ground ear corn.

The Pennsylvania, New Jersey, New York, Ohio, New Hampshire, and Oregon stations have investigated the use of sodium bisulfite as a silage preservative. Preliminary tests indicate that it is more eco-

nomical and more easily applied (being in powder form) than any preservative now available.

The Pennsylvania station reports that bisulfite-treated grass silage is green in color and possesses an odor resembling fresh-cut crops. The carotene content of this silage is higher than either untreated silage or that preserved with molasses.

Sulfur dioxide appears to be a very satisfactory silage preservative, according to the New Hampshire station. Nicotinic acid and riboflavin are not greatly affected by sulfur dioxide, but this preservative destroys much of the thiamine in the silage. Sulfur dioxide, however, produces conditions in the rumen favorable to synthesis of thiamine by the animal.

The New Jersey station has made tests of dehydrated molasses and molasses dehydrated with dried brewer's grains as preservatives of grass silage. The latter was quite satisfactory, except for cost, but the dehydrated molasses used was too sticky to handle properly. Preliminary tests with sodium metabisulfite indicated that it has good possibilities, based on general appearance and palatability of the silage.

In New York, where timothy is the most commonly grown hay plant, farmers have hesitated to use nitrogen to increase yields because it was feared that the increased tonnage would lengthen the curing time and reduce hay quality. However, research at the New York (Cornell) station shows that doubling a ¾ ton per acre yield of timothy lengthened the curing time only 1 hour and trebling a ½ ton per acre yield lengthened the curing time 2 hours. The grades for the higher-yielding, nitrogen-treated hays were always as high or higher than the grades for the check plots.

The New York (Cornell) station also found that sodium metabisulfite and sulfur dioxide were the most effective silage preservatives in preventing fermentation losses. However, the station also learned that early-cut, unwilted forage could be made into satisfactory silage without a preservative.

The Ohio station showed that the use of tight boxes for holding a week's supply of silage may be economical for the small feeder. Labor is reduced and spoilage can be retarded by covering exposed surfaces with paper sealed with limestone.

In a hay-curing experiment at the Wisconsin station, it was found that substantial losses of carotene occur with all curing methods used on alfalfa and red clover but that the greatest losses result from exposure to moisture and sun combined. Crushing the forage usually increases the field-curing rate, but weather conditions, the density of the crop, and the degree of crushing are factors that have a marked effect on the field-curing rate.

The effects of crushing and maceration on grass and legume silage were also studied at the Michigan station. Thorough maceration speeded up fermentation and gave an improved silage. Ordinary crushing of both chopped and long forage did not increase the quality of silage in an upright silo but when the forage was placed in a trench silo, the crushing of the silage was apparently beneficial.

The type of harvesting method used for alfalfa hay apparently has little effect on preserving the carotene and tocopherol contents, according to preliminary trials by the Nevada station. Hay that had been

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stacked loose, baled, or chopped contained similar amounts of these vitamins. Examination of hay samples from ranches showed that the first cutting of alfalfa lost 60 to 80 percent of the carotene and tocopherol. The second cutting contained less of these compounds but losses of the compounds through harvesting were less. The carotene content of all samples met the dietary requirement for cattle and sheep.

Forage Crop Utilization

An increasing amount of research is being devoted to the nutritional requirements of animals and to improved utilization of forage crops. Such studies are of value to agronomists in their efforts to develop forage crops of better quality, of greater feeding efficiency, and economical to produce.

Because weather conditions in Alaska in 1952 were more favorable than normal, it was possible to produce good-quality bromegrass hay. In feeding trials at the Alaska station (coop. USDA) dairy cows on bromegrass hay produced as much milk as those fed bromegrass silage. The silage was more efficient, however, as it took 1 acre to grow the hay necessary for a cow to produce 1,235 pounds of milk in a 90-day period and only 0.8 acre to produce the silage necessary for the same amount of milk.

The New York (Cornell) station compared early-cut and late-cut grass silage with early-cut, barn-dried hay and late-cut, field-cured hay as feed for dairy cows. It was found that the cows consumed more of the early-cut silage and hay than the later-cut forage. Digestibility ranged from 70 percent for very early forage down to less than 50 percent for late-cut hay. Early cutting reduced the yield of the first cutting but the second cutting produced a high yield.

In a 2-week trial the Georgia station reports that dairy cows produced 43 percent more 4-percent milk on temporary pasture than cows on tall fescue pasture. The dry matter intake on the temporary pasture of oats-ryegrass-crimson clover was 35 pounds per day, of which 75 percent was digestible. Georgia dairy husbandmen have been able to maintain 1,000-pound Guernsey cows producing 50 pounds of milk daily on oats-ryegrass-crimson clover pasture without grain supplement.

The Utah station (coop. USDA) grazed a dairy herd on a high-yielding irrigated pasture and reported that during a 2-year period milk production averaged 12,803 pounds and butterfat 442 pounds. This pasture yielded 5,173 pounds of total digestible nutrients per acre per year and furnished 68.5 percent of the calculated total nutrient requirement of the cows.

At the Kentucky station cows grazed for 1 month on a good bluegrass pasture produced 94.4 percent as much milk as at the beginning of the test. Cows on pure stands of bromegrass, orchardgrass, and Kentucky 31 fescue averaged 93.3, 90.6, and 70.8 percent of their original production.

The New Hampshire station (coop. USDA) investigated the changes in composition of eight species of grasses during their growth. It was found that crude fiber, cellulose, and lignin increase and that ether extract, acid-soluble ash, and nitrogen decrease as the plants mature. On the basis of percentage of the original content, the changes in nitrogen and lignin are most striking.

At the Puerto Rico University station forage plants give very high yields and it has been found that grass-legume mixtures are superior to pure stands. Guinea grass and tropical kudzu made the best combination. Total production per acre and nutritive value were higher when the forage was cut at 40-day intervals. Protein content at 40 days was almost double that at 90 and 120 days, but lignin was much lower.

The New Hampshire station states that the time of harvest and method of storage of forage are important factors in determining the need for supplemental vitamin D for the dairy cow. Early-cut forage harvested in June was much lower in vitamin D or provitamin D than forage of similar maturity harvested later in the season.

Winter pastures have been found to be economical for carrying beef cattle through the winter in the South. At the Georgia station temporary pasture, composed of rye, ryegrass, and crimson clover, was superior to tall fescue for this purpose. Fescue, although giving a long grazing season, was only slightly better than a low-quality, dry-lot ration. Average daily gain for the cows ranged from −0.38 pound in dry lot to 1.27 pounds on temporary pasture.

The Indiana station compared second-cutting chopped alfalfa hay, which was artificially dried, with first-cutting alfalfa silage and corn silage as a winter roughage for dairy cattle. Alfalfa hay and silage were more effective in maintaining milk production than second-cutting chopped hay except when the corn silage was supplemented with soybean oil meal. Furthermore, more corn silage was consumed.

Pasture and forage crops research by the Maryland station has resulted in an estimated 500-percent increase in ladino clover pasture during the past 5 years. Beef gains of 420 pounds per acre were obtained on orchardgrass-ladino clover pasture.

Over a 2-year period, milk production and income above feed cost per cow were highest for animals grazed continuously and lowest for those that were barn fed, according to the Mississippi station. It was concluded that winter pasture is not only an economical source of feed for the dairy cow but that it also has a milk-stimulating effect over and above its feeding values.

The Mississippi station also reports that crimson clover-ryegrass pasture is one of the better combinations for finishing weanling beef calves. Such a pasture produced 301 pounds of beef per acre and provided a return above all cost of $26.41 per steer. Fescue-red clover pasture returned only $9.16 per steer.

Experimental pastures at the Missouri station (coop. USDA) have produced from 250 to 350 pounds of beef per acre per year and such pastures were profitable even with cattle selling at 20 cents per pound. Tall fescue and ladino clover was found to be one of the most profitable combinations. This station also learned that ewes on good bluegrass pasture with concentrate supplements received adequate nutrition during the pregnancy period. The lambs from such ewes were slightly smaller at birth and their dams produced less milk, but by market time they were almost equal in weight and finish to the lambs from ewes which received supplemental feed.

The high carrying capacity of irrigated pasture for sheep has been shown in a grazing test at the Montana station (coop. USDA). Mixtures seeded in 1949 and grazed for 3 years have carried from 12 to 16 yearling ewes per acre. Empire birdsfoot trefoil with Troy blue-

grass furnished an average of 2,029 grazing days per acre compared with 1,895 days for the standard Huntley mixture.

The Nevada station (coop. USDA) produced meat-type hogs profitably on a high roughage diet. Minnesota #1×Duroc pigs fed 10-, 30-, and 50-percent alfalfa rations reached 200 pounds at about 160, 170, and 190 days, respectively. Feed costs were reduced nearly 20 percent by using high amounts of alfalfa.

The superiority of grass-legume mixtures over straight grass seedings for sheep pastures was demonstrated by grazing tests at the North Dakota station. Alfalfa-bromegrass pasture seeded in 1951 provided over 1,000 sheep-days of grazing per acre in 1952. Other grasses and mixtures produced more forage but yielded fewer sheep-days of grazing.

The value of pasture in swine feeding is becoming more and more apparent. The North Carolina station, in a preliminary test, found that pigs self-fed corn on pasture needed only half as much corn per 100 pounds of gain as was required by pigs self-fed corn fortified with minerals and vitamins in dry lot. Better pasture management methods are needed to provide adequate swine pasture during unfavorable weather.

Maximum results from the standpoint of economy of production and animal health were obtained at the Pennsylvania station by allowing pigs access to a forage crop. Legume pasture furnished at least 30 percent of the protein required by the growing pig.

Forage Crop Production and Management

Included in grassland farming research are studies of methods whereby larger and more profitable forage crops and pastures can be produced and grasslands management improved.

Preliminary reports from the Colorado station indicate that commercial fertilizers added to the soil can produce additional feed on seeded pastures which have begun to decline in production and that in some cases fertilization may be economical on native ranges. The station also demonstrated the feasability of improving high-altitude irrigated meadows. Under the usual system of no soil treatment, no water control, and late harvest, 400 pounds of crude protein per acre were produced. When water was controlled and early and aftermath harvests were made the protein production was 1,200 pounds per acre. The addition of 160 pounds of nitrogen per acre, water control, and early and aftermath harvest, also, yielded 1,200 pounds of crude protein per acre but the protein was produced entirely from grasses as the nitrogen eliminated the clover.

The Florida station, using radioactive calcium as a tracer, found that under some conditions little or no downward movement of calcium occurred in the phloem of grass roots. This suggests that, in order to realize the maximum benefit of nutritional and water relationship of crops, available calcium in amounts necessary to support healthy root growth should be present throughout the entire soil volume within which root growth is desired.

The Georgia station demonstrated that using heavier nitrogen levels at seeding times stimulates early growth of forage crops but that later topdressings are necessary for continued winter growth.

The use of herbicides for weed control in forage crops is steadily

increasing. At the Maryland station chemical control of chickweed resulted in an average increase of 1 ton of alfalfa per acre. This increase represents a farm value of $15 per ton after all costs are deducted.

The Massachusetts station reports that, by applying adequate potash, increases of 30 to 80 percent in hay production were obtained for the first 3 harvest years. Although liberal amounts of potash fertilizer were applied three times each year, the grasses studied removed 79 to 94 percent of the application during the 3 years. This emphasizes the fact that it is not possible to increase the soil potassium reserves when producing large yields of forage grasses on many of the Northeastern soils.

Dallis grass is one of the most important perennial pasture grasses in the South but its usefulness is limited by its total susceptibility to the ergot fungus. Because of this susceptibility, seed supplies of Dallis grass are limited and there is danger of ergot poisoning of livestock. The Mississippi station is making good progress in the development of seed-producing and ergot-resistant strains. Seven progeny from a Dallis grass × *Paspalum malachophyllum* hybrid have proven to be highly resistant and immune to ergot.

Some years ago the New Hampshire station found that the cobalt content of forage tended to decrease as the yield per acre increased. This station has now determined that ladino clover, bromegrass, and timothy, grown on highly fertilized soil, is deficient in the amount of cobalt, copper, and iron needed by cattle. Dairy heifers fed these forages developed cobalt deficiency symptoms in about 6 months, and after this condition was corrected by cobalt supplementation other deficiency symptoms developed. Calves showed poor growth, poor body condition, and anemia; and fresh heifers lost flesh, declined rapidly in milk production, and developed anemia. The studies will be continued to determine the effect of these deficiencies on reproduction.

Experimental work at the Oregon station during the past year has demonstrated the value of improved pastures in producing dependable early feed. The unfavorable growing conditions during the fall of 1952 emphasized the importance of perennials as compared with annuals for fall and early spring grazing. Heavy early use of both native and improved pastures has resulted in improvement of range when the grazing pressure is removed in late spring to allow the perennials to make ample growth after the annuals die.

The Texas station reports that relatively high rates of nitrogen fertilizer in combination with phosphorus and potassium may be used economically in the production of bluestem hay in east Texas.

Dryland seeded pastures decrease in productivity even though maintaining stands as they become older. The Wyoming station (coop. USDA) learned that crested wheatgrass, Russian wildrye, and western wheatgrass respond to severe renovation as well as to applications of nitrogen. The degree of response, however, is directly related to the amount of spring moisture. The combination of renovation and fertilization gives higher production than either fertilization or renovation alone. In years of low amounts of spring moisture the increased production does not pay for the cost of applying fertilizer, but with ample rainfall a net gain of more than $15 per acre above the cost of the fertilizer and its application is obtained.

FIELD CROPS

Agronomic research continues to help meet both domestic and foreign needs by the releasing of new improved varieties of small grains, sorghums, cotton, soybeans, peanuts and other oil seeds, potatoes, sweetpotatoes, tobacco, and other crops. A number of these varieties, products of the breeding and genetic research programs of the stations and the Department, are listed and described in the accompanying table. The special adaptations and uses of several new corn hybrids are mentioned. Selected examples of current advances in cultural, tillage, irrigation, fertilizer, and harvesting practices that are of immediate practical value in crop production, are also given in the following pages.

Corn

New corn hybrids

Michigan 480, a new 105-day (relative maturity) Michigan station hybrid, surpasses several established hybrids in grain and fodder production and resistance to stalk and root lodging, is well adapted to clean mechanical harvest, and has a high shelling percentage. It may be grown as a medium early hybrid for grain and silage in southern and south-central Michigan and as a full-season hybrid in north-central Michigan, but frost hazard prevents its general adaptation on muck soils. Ohio W–49, a new yellow hybrid of the Ohio station (coop. USDA) has stalks and husks that dry fast after kernels fill. Farmers in central and northern Ohio wanting to harvest with pickers soon after maturity are expected to like Ohio W–49.

M–1 and M–4, new early maturing, stiff-stalked, high yielding, disease-resistant corn hybrids developed by the New York (Cornell) station, are expected to increase grain and silage yields by from 8 to 10 percent. They may yield as high as 100 bushels of dry shelled corn per acre or 18 tons of nutrient-packed corn silage.

Pa 444, one of 3 new hybrids of the Pennsylvania Station, recommended for high altitudes and shorter season areas, matures between Wisconsin 412 and Ohio M 15, both of which it surpasses in root and stalk and which it outyields by more than 8 bushels per acre. Pa 602 A, another productive hybrid, is recommended for central Pennsylvania on well-fertilized soils. Pa 807 is a drought-tolerant, long-season hybrid, for southeastern Pennsylvania, much superior to older hybrids in tolerance and resistance to borers and aphids.

South Dakota 220, developed by the South Dakota Station, is earlier than any station hybrid released to date and is adapted to the northern part of the State. Texas 30, a productive Texas station hybrid, bears large ears with yellow, dented kernels, resists root lodging and stalk breakage, and is the most resistant of the yellow Texas hybrids to earworms and ear rots. It is recommended for all Texas corn-raising areas except the western area.

Purdue 202, a new yellow popcorn hybrid developed by the Indiana station (coop. USDA), is the first large-kerneled yellow hybrid available in the early maturity group. It stands well, silks earlier, and has a lower harvest moisture content than any Purdue hybrids released previously, and its expansion has averaged 34½.

Crop	Variety	Station and cooperation	Type	Noteworthy characteristics	Resistance to crop pests	Adaptation
Wheat	Concho	Oklahoma USDA	Hard red winter	High yield, moderately stiff straw, bearded, medium maturity. Good to very good milling and baking quality.	Highly resistant to bunt, somewhat less resistant to leaf rust than Ponca, moderately susceptible to loose smut and to stem rust.	Hard red winter region.
	Frisco	Texas USDA	Soft red winter	High yielding, early, similar to Red May in quality—for family flour.	Resists prevalent races of leaf smut and common races of stem rust, but not 15B.	North central Texas.
	Stewart-211	North Dakota USDA	Durum	Resembles Stewart, which it outyields, threshes easier, and has better straw.	Resists several races of stem rust	Durum area.
Barley	Cordova	Texas USDA	Winter (intermediate).	High test weight and yield, smooth awn, nonshattering. Stands well for combine harvesting.	Resists some races of mildew and loose smut.	Central and Rolling Plains of Texas—fall or spring seeding.
	Custer	Utah, Nebraska USDA	Spring	Outyields standard varieties in Nebraska. Earlier and stiffer strawed than Velvon 11 on which it is an improvement.	Susceptible to loose smut and stem rust.	Western Great Plains.
	Davie	North Carolina	Winter (intermediate).	Good winter survival, little lodging, ripens in midseason. Compares favorably with Colonial.	Good resistance to leaf rust and mildew. Susceptible to loose smut.	Piedmont, North Carolina.
Oats	Alamo	Texas USDA	Winter (early)	Productive, strong straw, early, upright, companion with sweetclover.	Moderately rust resistant	Grain and forage (south Texas); grain (north Texas).
	Clintafe	Iowa USDA	Spring (early)	Resembles Clinton in most features; later and taller.	Resists stem rust, adds crown rust (race 45) resistance from Santa Fe, tolerance to Septoria.	Corn Belt.
	Clintland	Indiana USDA	Spring	Resembles Clinton	Crown rust resistance from Landhafer.	Corn Belt.
	Delair	Arkansas, Mississippi. USDA	Winter (early)	Very early, vigorous, tall, stiff straw, upright; ripens 2 weeks before full season varieties; early fall pasture, precedes soybeans.	Resists Victoria blight; escapes serious rust damage.	Delta: Arkansas, Mississippi.
	Dubois	Indiana USDA	Winter	Winter-hardy, stiff straw, gray-white kernels.	Resists Indiana smut races; susceptible to new crown rust races.	Indiana—South of US-50.
	Floriland	Florida USDA	Winter (intermediate).	Early, upright, red kernels	Resists crown rust and Victoria blight; escapes stem rust and is more resistant to culm rot than Southland.	Florida, Gulf coast.
	LaSalle	Illinois	Spring	Earlier than Clinton, weaker straw, about as tall; has outyielded Clinton in central and southern Illinois, but yields less in northern Illinois.	Some resistance to crown rust race 45, some resistance to stem rust, resists smut.	Illinois.

Newly developed crop varieties—Continued

Crop	Variety	Station and cooperation	Type	Noteworthy characteristics	Resistance to crop pests	Adaptation
Oats	Park	Montana USDA	Spring	High yield and quality, short stiff straw, uniform height, plump white kernel.	Resists smut; some resistance to stem and crown rusts and Victoria blight.	Irrigated areas of Montana, Idaho, Utah, and Washington.
	Sauk	Wisconsin USDA	Midseason	High yield, straw stands up well on fertile soils.	Resists Victoria blight, moderate resistance to stem rust and smut, intermediate for leaf rust.	Wisconsin.
Rice	Sunbonnet	Louisiana USDA	Long grain	Surpasses Bluebonnet in yield, percentage of whole kernels, better stands.	Resists cercospora leaf spot, susceptible to kernel smut.	Louisiana and Texas.
Sorghums	Relianee	South Dakota	Grain	Midlate, stands longer after killing frost, has larger (red tan) seed and sturdier stalks than Norghum, open seed panicle, well above flag-leaf.	Less susceptible to leaf stripe and leaf bloteh than Sooner milo.	Sorghum areas of South Dakota.
	Tracy	Mississippi USDA	Sirup (midseason).	Ereet-lodging resistant stalk—surpasses White Afriean in sirup per ton of stalks and per acre. Juiee has high total sugar content and makes larger yields of high quality sirup.	Resists leaf anthraenose and red rot.	South.
	Okaw (broomcorn).	Illinois	Standard	Tan brush; stays green while euring; easier to dye during manufaeture.	Resists stalk rot	Illinois.
Cotton	Coastland	Georgia USDA	Sea Island	Yields superior to old sea-island varieties. Spinning properties equivalent to Egyptian Karnak.		Southeastern United States.
Soybeans	Clark	Nebraska, Iowa, Illinois, Indiana, Missouri. USDA	Grain	High in yield and oil content, yellow seed with blaek hilum. Averages 5 bushels per aere over varieties of similar maturity in its adapted area. Resembles Lincoln, but is 1 week later.	Resists frog eye-leaf spot	Southern part of Corn Belt—Kansas, Nebraska east to north Kentueky, and eastward. Southern edge of Lineoln variety zone.
	Jaekson	Southern States. USDA	Grain	High yields, oil content, and seed quality; yellow seed; slightly later than Roanoke; economieal produetion. Resembles Roanoke and Volstate but better adapted to lighter soils of the area and responsive to fertilizer.	Resists lodging	Light soils, south-central Virginia, southwest to northeastern Louisiana. Area of Roanoke variety.
	Yellow Gatan	Georgia	Hay	High yields of seed and hay, yellow seed with blaek hilum, 16 pereent oil eontent.		Georgia.
Peanuts	Virginia Bunch 46–2.	Virginia USDA	Upright buneh	High yields, high proportion (20–50 pereent) of shelled seed extra large; high quality of processed product—dry roasted, butter, or salted.		Southeastern Virginia.

Lupine	Alta Blue	Florida	Bitter	Wide soil adaptation, heavy seed production, large yields of green material for soil improvement.	High resistance to anthracnose	Florida.
Potatoes	Dazoc	Nebraska	Early	High yield of US No. 1 tubers, smooth round, superior market and cooking quality, especially deep-fat frying.	Practically no cracking at harvest	Irrigation in central and western Nebraska. Dry land in western Nebraska.
	Early Gem	Idaho, North Dakota. USDA	Early	Medium-long shallow-eyed, russet-skinned tubers, satisfactory cooking quality. In North Dakota, outyields scab-susceptible Irish Cobbler and Triumph. In Idaho, surpasses immature Russet Burbank in market qualities.	Highly resistant to scab; susceptible to late blight and virus.	Certain areas in Idaho and North Dakota.
	Osage	Iowa USDA	Early	Oblong, smooth, shallow-eyed tubers; yields more US No. 1 tubers than Irish Cobbler which it equals in time of maturity and cooking quality.	High resistance to scab, susceptible to late blight; tendency to hollow heart reduced by close spacing in row.	Scab-infested soils of North Central States.
	Sheridan	Nebraska	Early	Tubers smooth round to slightly oblong, superior to Triumph in appearance, and market and cooking quality—suitable for deep-fat frying. Slightly later than Dazoc.	Practically no cracking at harvest	Irrigation in western Nebraska.
Sweetpotatoes	Kandee	Kansas (Louisiana).	Bush	Uniform root shape, orange flesh, high in carotene and ascorbic acid.	High resistance to black rot	Kansas area.
	Nemagold	Oklahoma	Jersey	High yield, orange color flesh, above Jersey type in carotene, good ascorbic acid content—medium size, smooth roots.	Resists nematodes, tolerates soil rot; less susceptible to stem rot, wilt, and black rot than other Jersey varieties.	States north and east of Oklahoma.
	Redgold	Oklahoma	Moist flesh	High yields, attractive market appearance, greatly outyields All-gold and "Unit 1 Porto Rico" in No. 1 roots.	Resistant to stem rot or wilt	Oklahoma and adjoining States
	Sunnyside	Maryland USDA	Moist flesh	High yield, good canner, expected to replace Maryland Golden.	Resists cracking, some resistance to black rot but none to fusarium wilt.	Eastern Shore of Maryland.
Tobacco	Burley 2	Tennessee USDA	Burley	Easy to grow, ripens uniformly, produces a high percentage of cigarette-grade leaf. Resembles Ky. 16 in appearance, acre yield, and value.	Moderately resistant to black root-rot, not to other diseases.	Tennessee and other burley areas where thinner bodied types have not given desired yields and when Burley 1 may fire excessively.
	Dixie Bright 28	North Carolina. USDA	Flue-cured	Outyields Dixie Bright 27 and Oxford 26. Leaves not too brittle, evenly spaced on stalk, and easy to cure to a bright color with porous open-grained texture.	High resistance to bacterial (Granville) wilt, but not to black shank.	Upper North Carolina, Middle Belt and in Border Belt counties where black-shank is not a problem.

Advantages of mulch tillage with corn

Corn yields close to average have resulted from use of the mulch tillage planter by the Illinois station—89 bushels compared to 95 bushels per acre by the conventional method, both with 66 pounds of applied nitrogen and about 12,000 plants per acre. Advantages of mulch planting are: The farmer has to go over his fields only once compared with four or five times with the conventional method, and ground cover remains up to the time of the first cultivation, thus conserving soil and improving its physical condition.

Intercropping wide corn rows promising

The Ohio station finds promising the practice of planting corn in wide rows (70 inches apart) and sowing wheat or legume crops between them. When soil and weather are good enough to produce 75 bushels of corn per acre, rows 50 inches apart will yield as high as rows 30 or 40 inches apart, provided the number of plants per acre are alike and adequate. The economical practice, the station concludes, is to plant an adequate number of plants of a midseason or full-season adapted hybrid in 70-inch rows, seed wheat on the hessian-fly-free date in unharvested corn, or plant plow down or meadow crops between corn rows in summer, and delay corn harvest until the crop is in proper condition.

Manure at planting maintains yields

Corn receiving manure (8 tons) or straw (2 tons) at planting time at the Ohio station (coop. USDA), made as good yields as corn on land where manure was plowed under; soil loss was reduced to about 1 ton per acre; and rain runoff was cut in half. When manure was applied soon after planting and 2,4–D to keep down weeds, and no cultivation was given, corn yielded 95.1 bushels per acre; the same treatment plus one cultivation averaged 107.7 bushels. The ordinary manure spreader did not damage corn in 42-inch rows. Need for more plants per acre could be met by closer spacing in the row.

Nitrogen good for continuous corn

The Ohio station also found that plowing down 100 pounds of elemental nitrogen per acre with continuous corn boosted yields to 70 bushels even after 7 to 9 years of continuous corn crops; with a good rotation—corn, oats, and sweetclover—orchardgrass combination, yields went much higher. The station points out that low-grade organic matter plus nitrogen often can do as much for soil fertility as high nitrogen sod from legumes.

Nitrogen for corn best in complete fertilizer

The Virginia station found that nitrogen could be applied to advantage in the complete fertilizer at or before corn planting on the heavier soils, such as Davidson clay loam, and thus eliminate the costly and time-consuming practice of side-dressing nitrogen when corn is 12 to 15 inches tall. Plant stand and number of ears were slightly greater at harvest, whereas moisture content was slightly less with the nitrogen in the complete fertilizer.

Planting rate for corn

Optimum planting rate of corn depends largely on soil fertility and water-holding and storage capacity according to the Tennessee station. Its extensive spacing-fertility experiments on good corn soils—moderately level, deep, friable, and well-drained—determined that a population of 7,000 to 9,000 plants per acre, fertilized with 60 to 90 pounds of nitrogen and adequate phosphorus and potassium would result in optimum yields. Acre spacings recommended are: 6,000 plants for 60-bushel yield and 10,000 plants for 100-bushel yield. A stand of not over 12,000 plants was best for a full-season prolific hybrid in experiments providing highest yields.

Working on Norwood silty clay loam, the Texas station finds that for best yields and adapted hybrid such as Texas 24 should be fertilized with 60 pounds each of nitrogen and phosphoric acid but no potassium, with a stand of 6,500 or more plants per acre. Yields from within-row spacings of 12, 18, or 24 inches were similar. The hybrid outyielded a good open-pollinated variety by 12 bushels per acre or 30 percent across all treatments.

Fertility practices give high yields on poor soils

Through adoption of proper soil management and fertilizer practices indicated by Missouri station research, corn yields of 100 or more bushels per acre can be produced on soils once considered unsuitable for the crop. A 100-bushel crop requires from 160 to 215 pounds of nitrogen, 45 to 80 pounds of phosphorus (P_2O_5), and 90 to 175 pounds of potash (K_2O). Fertilizers will supply needed additional elements not released from the soils. Thick stands needed for maximum utilization of added nutrients provide residues which can add more organic material than will any other crop normally grown in the Corn Belt and also afford protection during winter.

Popcorn dried without harm to expansion

That popcorn can be harvested with moisture content as high as 30 percent and dried artificially at temperatures up to 130° F. without injury to popping expansion was determined by the Illinois station. Popcorn is difficult to dry to the determined moisture level of 13 percent, yet experiments indicated that the kernels may be over-dried to 9 or 10 percent moisture, which is easier to control, and then be reconstituted to the desired moisture level by blanching in live steam with a standard cannery blancher having a fine-mesh metal conveyer belt. Blanching bleaches popcorn to a brighter and more attractive shade. Blanched samples, canned and held in an incubator at 98° F. for longer than 2 months, showed no spoilage or deterioration in popping expansion, which equaled that of crib-dried popcorn.

Wheat

Wheat yields boosted by early plowing

Every week that plowing is delayed after wheat harvest reduces the wheat yield 1 bushel per acre, according to the Kansas station. Early plowing liberates plant food nutrients in the soil and increases soil moisture content by reducing runoff, allowing water to be absorbed,

and killing weeds. Depth of early plowing had little effect on wheat yields over 32 years of experiments. Land plowed 3 inches deep in July averaged 23.7 bushels per acre, 7 inches deep 25 bushels, and 12 inches deep 24 bushels. There were wide differences in yield under different time-of-plowing practices over the 32-year period. July-plowed land produced 25.1 bushels an acre, August 20.5 bushels, and September-plowed land 15 bushels.

Time of tillage affects wheat yields

That moisture conservation is the major consideration for southern plains farmers who grow winter wheat, and that time of tillage has more effect on moisture conservation (and yield) than any other controllable factor, were determined by the Oklahoma station (coop. USDA). Neither the type of tillage implement used nor the depth to which it is operated has had much effect on yield, as long as the practice followed controls weeds. Implements leaving straw or other residues on the surface have helped to control erosion. Tillage must be frequent enough to prevent weeds from wasting moisture. Although summer fallowing has not been profitable as a regular practice, its use has been justified under special conditions. Yields of wheat after sorghums have been much lower than of wheat after wheat. Rotations designed to build up the soil have not greatly increased crop yields or reduced losses of soil organic matter and nitrogen. Fertilizers have produced yield increases that are profitable on the average, but not in most years. Wheat has responded to both nitrogen and phosphorus.

Wheat responds to small nitrogen applications

Application of commercial nitrogen to dry-land winter wheat by the Utah station resulted in increases in yield or protein content or both, decrease in yellow berry content with increase in protein content, but seldom increases in weight per bushel. Although 40 pounds of nitrogen per acre appeared to be the most profitable rate, less or even none is advised where soil moisture is too low. The nitrate form was more effective than the ammonium when applied in spring, yet both forms were about equally good when applied in fall. Early spring applications were more effective in northern Utah, whereas spring and fall treatments were equally effective at Nephi.

Grain sorghum thrives in narrow rows

Growing grain sorghums in 21-inch rows compared to the generally used 42-inch spacing, the Kansas station reports, has provided as large or larger yields, even in years with dry midsummers. The 9-year-average yields have been 25 percent greater from the narrower rows. Plants in the 21-inch rows also shade soil between rows, retard weed growth, and slow evaporation.

Fiber and Oil Seeds

Producing cotton for mechanized handling

Experiments on production methods adapted to mechanized handling of cotton by the California station (coop. USDA) have shown

that for highest yields and best use of picking machinery, cotton plants per acre should number at least 20,000 and not more than 60,000. Relatively large numbers of plants per acre helped to overcome the tendency of machine pickers to miss bolls growing close to the ground surface; resulted in development of the lowest bolls at a greater-than-usual height from the ground; produced taller plants with fewer and smaller lateral branches, and thus increased the efficiency of the machine; and reduced the quantity of litter picked up. Weed control by flaming was effective and did not reduce the yield of cotton, but could be used only from the time the plants were about 8 inches high until the first bolls opened.

Closer spacing better for upland cotton

Closer spacing of cotton in the row by the Oklahoma station has decreased preharvest loss and the amount of trash in harvested cotton, and has increased gross yields of lint and the efficiency of the stripper harvesting machine. The New Mexico station (coop. USDA) found that heavier stands of plants resulted in higher yields of seed cotton per acre. The percentage of plants showing verticillium wilt symptoms on infested soil have been lower on areas with heavier stands. More plants evidently escape the attack of the wilt fungus and produce a crop of bolls. Beneficial effects of heavier stands obtained on fields varying widely in soil type and levels of fertility, suggest that this practice is not limited in its application.

Storage of valuable cotton seed stocks

Breeding and genetic studies with cotton have stressed the need to maintain the vitality of small valuable lots of seed for periods longer than ordinarily possible in air-dry storage. The Tennessee station (coop. USDA) finds that cottonseed may be stored safely in sealed containers for longer than 10 years by controlling moisture and temperature of storage and without special techniques or storage facilities. The procedure is to dry the seed to about 7-percent moisture, at a relatively low temperature—under 140° F. for seed with initial moisture above 8 percent—seal it in airtight containers, and store it in a cool place, under refrigeration of about 33° F. Refrigeration, however, is not essential if the seed is dry.

Oil and protein contents of cottonseed

Seed of cotton varieties grown under dryland conditions by the Texas station had higher averages of both oil and protein than seed from plants grown under irrigation. Oil contents of stormproof-type cottons averaged consistently higher and of protein contents slightly higher than those for the normal boll types, but the average linters yield of stormproof seed was considerably less.

Irrigation of cotton profitable in the South

Irrigation of cotton, in Mississippi station experiments, produced a crop worth an average of $93 more per acre than nonirrigated cotton. Irrigation totaling 6 inches of water in 5 applications cost $25.80 per acre including labor, fuel, and annual cost of sprinkler equipment. Yields ranged from 665 to 977 pounds of lint per acre under irrigation

and from 533 to 720 pounds without. Irrigation had slight effect on lint percentage and staple lengths but reduced the number of bolls needed for a pound of lint by about 9 percent. The moderately vigorous cotton varieties currently being grown appeared best for this type of irrigation.

Flax plant fat content increased by soil nitrogen

The possibility of increasing the fat content of the vegetative parts of plants was shown by the Arizona station. In greehouse-grown flax the yield of fat in the shoot (excluding seeds) could be raised from 1.5 to 6 percent on a dry-weight basis by growing the plants at high or low levels of nitrogen and then changing to very low soil nitrogen. Seed fat yield was also increased slightly by this method. Time of flower formation was not affected, but the number of seeds per plant was affected greatly by changes of soil nitrogen. In some cases the greater yield of fat was offset by fewer seeds.

Soybeans vs. corn at different fertility levels

At intermediate soil productivity levels, at which corn yields of between 50 and 80 bushels per acre are obtained, experiments of the Iowa and other stations indicate that the yields of soybeans can probably be increased as much as the yields of corn, percentagewise, by improving fertility through lime, fertilizer, and manure in the rotation. At very low productivity levels soybeans usually have an advantage in relative yields over corn; even under these conditions profitable soybean production cannot be anticipated. At very high soil-fertility levels corn may have a relative advantage over soybeans—especially if the soil responds to increasing amounts of nitrogen and other soil factors are at optimum.

Defoliation of soybeans

In Illinois station experiments early applications of defoliants, until approximately 40 percent of the soybean leaves have turned yellow have resulted in the ripening of the crop a few days earlier; but also have resulted in severe losses of yield. These effects have not been evident with later applications. The ripening and harvesting of weed-free soybeans could not be sped up materially without substantial reductions in yield. Defoliants have dried up green growing weeds in mature soybeans and greatly hastened harvest, but evidently do not have a place in speeding up maturity in weed-free fields.

Rancidity in Spanish peanuts and its elimination

Spanish peanuts tend to become rancid faster after processing than Virginia or runner types, according to Georgia station studies. Oxidative rancidity, evident in the oil of this type soon after roasting for either salted nuts or peanut butter, is associated with a slightly different percentage of component unsaturated fatty acids in the oil of Spanish-type nuts. Since Spanish-type nuts possess a number of desirable characteristics and are very popular, efforts are being made to select Spanish strains in which oil composition approaches that of Virginia and runner types.

Hybrid castorbeans

The development of hybrid varieties of castorbeans is another long step toward increased profitable production of this crop for industrial uses over wide areas in the Southwest. Hybrid castorbeans, produced by crossing N145–4 (a female line developed by the Nebraska station) with selected inbred lines and commercial varieties, have yielded from 15 to 20 percent more beans per acre than any commercial variety now grown. In Oklahoma station tests (coop. USDA) the hybrids of N145–4 with USDA74 and with Cimarron (locally adapted varieties) yielded 1,030 and 1,009 pounds of beans per acre, respectively, compared with 875 pounds for USDA74 and 838 for Cimarron. In cooperative tests under irrigation with the California station the hybrid of N145–4 with USDA250 yielded 3,936 pounds per acre compared with 3,308 pounds for USDA250. The hybrid of N145–4 with Baker 195 (a leading semidwarf variety) made 3,497 pounds compared with 3,010 pounds for Baker 195.

Potatoes and Sweetpotatoes

Control of size of tubers for seed

Potato tubers below 2⅞ inches in length are the most desirable in size for seed. The Maine station finds that the practice of close seedpiece spacing (in rows not closer than 30 to 32 inches or 30 to 36 for Katahdin and Kennebec), together with moderate application of fertilizer (2,000 pounds 6–9–9 or 1,500 pounds 8–12–12 per acre), proper storing, and killing the vines when tubers reach the desired size, are important factors in controlling tuber size. This also applies to Kennebec and similar varieties for table stock. Thiourea treatment has aided in reducing tuber size but usually at expense of total yields.

Skin color and other characters affected by 2,4-D

The Colorado station (coop. USDA) has found it possible to increase the vitamin C content and in harmony with Minnesota station studies, to intensify the red skin color of Red McClure potatoes, without a depression in yield, by treating plants prior to harvest with small amounts of the sodium salt of 2,4–D. When treated tubers were desprouted and planted, no significant differences in stems, number of stems per plant, or yield were noted. Treatment resulted in an increase of free glutamic acid and a decrease of 11 other amino acids, but in no change in the nitrate content (i. e., not enough to be toxic). Such treatment with 2,4-D also produced tubers with significantly higher protein content and higher specific gravity.

Phosphorus for Maine potatoes

Field experiments on rate of application, placement, and sources of phosphorus, aimed at increased efficiency in the use of phosphorus fertilizers for potatoes, conducted by the Main station during 25 years, indicate that the currently recommended application of 160 to 200 pounds of P_2O_5 per acre from superphosphate in row side bands is still satisfactory in obtaining high yields of Maine potatoes.

Ethylene chlorhydrin for sprouting sweetpotatoes

Because they give poor sprouting, several new sweetpotato varieties with excellent flavor have been neglected by farmers. Under a technique developed cooperatively by the California and Texas stations, ethylene chlorhydrin stimulated sprouting better than any other method (including chemicals and heat treatment) on nearly all varieties tested.

Tobacco

Harvesting burley tobacco for best returns

The optimum time for harvesting burley tobacco, based on crop value, the Tennessee station (coop. USDA) finds, is 25 days after topping. In their experiments tobacco was harvested beginning about August 15—7, 13, 19, 25, 31, 37, and 43 days after topping. Improvement in grade quality and yield resulted in an increase in crop value of about $300 per acre from the first to fourth harvest, and a decline of $300 from the fourth to the seventh harvest. Appreciable losses have resulted from either cutting the crop while tobacco is too green or delaying harvest unduly. Growers would receive maximum returns per acre if they began early enough, as with one or more primings, to permit harvest of much of the crop at the optimum stage, instead of beginning at the optimum stage and completing the harvest when tobacco is overmature. Results show that, irrespective of harvest date, the lower leaves on the plants have physical properties and chemical composition presently desired for use in cigarette manufacture. Certain desirable chemical changes were found to occur as leaves at different positions on the stalk reached the optimum stage of maturity.

Plant bed fertilizers

Fertilizers should be applied to tobacco plant beds at rates consistent with the nutritional needs of the plants; excesses detrimental to seed germination or that will produce weak, overly succulent plants should be avoided. Plant bed studies with burley on Cumberland, Dunmore, and Nolichucky silt loams by the Tennessee station (coop. USDA) indicated that ½ to 1 pound per square yard of 3–9–6 fertilizer, or its equivalent, with the nitrogen not entirely in the nitrate form, is adequate for production of tobacco plants in the area concerned (Greenville). When applied at time of seeding, ammonium nitrate, ammonium sulfate, and a mixture of nitrogen sources were about equally effective in producing early plants.

Fertilization and the control of weeds in tobacco plant beds can be carried out in one operation as the result of research by the North Carolina station. The one-treatment mixture developed contains the essential plant nutrients for seedlings, plus herbicides for control of common weeds infesting tobacco beds. Offered as a special plant bed (16–6–2) fertilizer by dealers, the mixture is applied at the rate of 3 pounds per square yard in the fall, 60 to 90 days before seeding the beds.

Fertilizers for flue-cured tobacco

Experiments made by the Florida station on fertilizing flue-cured tobacco on Norfolk fine sand indicate that the best practice is to make a side placement 7 to 10 days after transplanting of a 3–8–8 fertilizer containing 2 percent magnesium (½ water soluble) and not over 2 percent chlorine, when high rates are used; reserve part of the fertilizer for later application in case of leaching of the soil by rains early in the season; and refrain from growing tobacco immediately after a legume crop. A nitrogen ratio of one third each from sodium nitrate, ammonium sulfate, and urea produced highest yields with good quality. Cottonseed meal, soybean meal, and dried blood were preferable to many other organic nitrogen carriers. Fertilizer rate will range from 1,000 to 1,600 pounds per acre, depending on soil type and organic matter content, and the number of plants from 5,000 to 7,000 per acre depending on fertilizer, soil type, and moisture-holding capacity.

About 1,400 pounds of 3–10–10 fertilizer per acre was the maximum rate at which good quality smoking tobacco could be produced with flue-cured varieties in experiments by the Georgia Coastal Plain Station (coop. USDA) on Norfolk and Tifton sandy loams. Increasing the fertilizer from 1,000 pounds to 1,400 pounds resulted in a gain of $115 in acre value; and increasing it from 1,400 to 1,800 pounds gave a further increase of only $28. Application of additional fertilizer gave greatest increase in returns when moisture was not a limiting factor. As compared with low rate of application, ripening was delayed about one week when the high rate fertilizer was applied.

Fertilizer placement for cigar tobacco

Placing half of the fertilizer for Havana Seed tobacco on the plow sole and harrowing the remainder into the upper soil gave higher yields in Connecticut Agricultural Experiment Station studies than the usual method of broadcasting all the fertilizer after plowing and then harrowing it into the upper few inches. The better distribution under the first method made the plant food available at both deep root and upper levels. Both methods were superior to broadcasting before plowing, drilling in bands close to the row, or placing all the fertilizer on the plow sole.

VEGETABLE RESEARCH

Quality in Vegetable Crops

Quality and quality control are subjects foremost in the minds of vegetable crop research workers. Better grading standards, elaborate refrigerated display cases in large supermarkets, the introduction of transparent plastic wraps and window bags, even improvements in color illustrations for canned goods, all have stimulated greater demands for higher quality vegetables.

The Indiana, New York State, and Ohio stations (coop. USDA), recognizing the marked importance of canned tomato products, have been engaged in research that may have considerable effect on the

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marketing and consumption of tomatoes. Its importance is realized when one considers that the farm weight of canned tomato products alone consumed annually in the United States averages better than 35 pounds per capita. This research is a cooperative study in which the grades of various tomato varieties are studied as raw material and these grades correlated with the grades of the canned products. Complex new scientific instruments have been devised for measuring objectively color of fruits and fruit products in these tests. Many other factors have been studied to discover ways and means by which a premium can be assured the grower of high quality tomatoes and the consumer a high quality product through accurate and reliable grading for quality.

Fresh sweet corn has long been considered a perishable product in which quality is soon lost, particularly during the warmer weather prevailing as corn is being harvested. Higher temperatures cause the natural sugar flavor of sweet corn to change rapidly to a flat, starchy taste that has little appeal to a consumer who has once enjoyed the taste of high quality ears. The widespread expansion of modern packaging, cooling, and refrigeration of fresh produce offers new potentialities for extending the market for fresh and processed sweet corn. The Minnesota station, as part of a regional project (coop. USDA) is trying to find methods of increasing sales and standards of sweet corn by improving handling practices in the marketing process. In the North, where summer temperatures are lower, the need for refrigeration is not as pronounced as in regions farther South. Nevertheless, the research indicates that further improvement in methods of handling it will result in higher quality sweet corn on the table of the consumer.

In connection with this regional study, the Indiana station is currently engaged in a broad economic study of the marketing of both fresh and processed sweet corn, with particular reference to quality and methods by which it can be conserved for the mutual benefit of the sweet corn industry and the consumer.

The feasibility of using wet-strength paper bags to ice sweet corn is under study as part of a northeastern regional project at the New Jersey station. How this method of merchandising will affect product quality is a feature of the research. Also in connection with this regional project the quality of sweet corn is under investigation at the New York (Cornell) station (coop. USDA). The practicability of using wet-strength paper bags in conjunction with icing, the resulting temperature influence, and the effect on the ultimate quality of the sweet corn as indicated by consumer taste panels have all been noted in this study.

In connection with a regional research project in the Southern States, the Florida station (coop. USDA) is also working with wet-strength paper bags to determine their practicability as containers for sweet corn iced to retain quality. The higher the air temperature in the field when sweet corn is harvested, the more quickly the ears will decline in quality unless means are provided quickly to lower their temperature.

New Vegetable Varieties

In the development of new varieties, the vegetable plant breeders at the State stations have made noteworthy progress in the past year.

A new asparagus variety, Waltham Washington, has been developed by the Massachusetts station. Through uniformly vigorous yielding plants this new asparagus has produced yields that are 50 percent above other commercial varieties. Waltham Washington closely resembles the Washington variety in size, color, and resistance to rust. Seed is expected to be available commercially in 1956.

At the Wisconsin station a new snap bean, Badger Bush Refugee, shows great promise. It is especially suited for mechanical picking. Nearly all of the beans are ready for harvest at one time, a factor upon which the success of the mechanical picker depends in part. It matures 3 weeks earlier than Idaho Refugee and is mosaic-resistant. The dark green beans yield well and are excellent for canning.

In California a new lima bean is being introduced for production under the climatic conditions of the interior valley area. It is to be named Mackie after the late W. W. Mackie, University of California agronomist, who pioneered its development, which was completed by one of the California station workers at Davis. The new lima is a large-seeded, dry-edible type and was released in the fall of 1953.

Pennvalley is the name given a new yellows-resistant cabbage that has been announced by the Pennsylvania station. This attractive variety has given yields at State College equal to those of its predecessor Penn State Ballhead, to which it is quite similar. The head of the new variety is carried well off the ground and the stem is relatively long. Sufficient seed is thought to be ready to meet all needs in 1954.

Badger Market is another yellows-resistant cabbage that has been announced jointly by the Wisconsin station and the U. S. Department of Agriculture. It was developed from a cross between two yellows-resistant varieties, Globe and Racine Market. The new variety has a smaller head than that of its parents, but the size is one for which there is considerable consumer preference. It is an early maturing cabbage, which, when cut open, reveals an attractive display of tender, crumpled leaves. Adequate seeds will be available from seedsmen in 1954.

A new pickling cucumber has been developed that, through its resistance to disease, has saved some 50,000 Wisconsin pickle growers hundreds of thousands of dollars. This new cucumber, named the Wisconsin SR6 by its developers at the Wisconsin station, is scab and spot-rot resistant and has been received with great enthusiasm, particularly in the northern part of the State.

The Hawaii station has announced a new lettuce variety named Kaala. This variety, adapted for summer heading in Hawaii, has shown outstanding performance in yield, earliness, and tolerance to *Rhizoctonia* bottom rot, even at elevations below 600 feet. It excels the variety Manoa in resistance to tipburn, but is surpassed by the variety Great Lakes in this respect.

The Golden Pershaw muskmelon has been released by the California station to the seed trade. It is a high quality fruit and is expected to rate favorably with the Crenshaw and Persian.

Two new onion varieties have recently been announced in an extensive breeding program in which a number of State stations are working cooperatively with the Department. In this case the two varieties, L36 and L365, were developed with the Texas station. These varieties are of particular interest to the South since they are highly resistant to the dreaded pink root that can cut yields in some of the

early commercial varieties. L36 is an extra-early yellow Bermuda type, while L365 is a Crystal Wax type. L365 has consistently outyielded the early standard commercial variety L690. It is estimated that about 3,000 pounds of seed of each of the above varieties were available from commercial seedsmen in the fall of 1953.

In the same breeding program the Idaho station (coop. USDA) has released a limited supply of seed of a new onion inbred with the number B12115. The purpose of this release is to make available to the seed trade pollen that has exhibited outstanding combining ability when used as a pollen parent with numerous male-sterile lines. B12115 is a good seed producer; hence, no difficulty is anticipated in maintaining a stock.

The Wisconsin station has announced a new pea named New Era, which is resistant to both wilt and near-wilt and promises to be a high yielder of peas of good canning quality. New Era is ready for canning 2 to 3 days earlier than Wisconsin Perfection. New Era is a definite improvement over Delwiche Commando, the only other well-known variety that is resistant to both wilt and near-wilt.

A new variety has been added to the list of improved varieties of Southern peas. This is Texas Cream 12, a fusarium-wilt and root-knot nematode-resistant kind that has been derived from the old Blackeye 8146. Texas Cream 12 is a distinct bush type plant that matures medium early. The pods are readily harvested by machine or by hand. Although the seeds are small there are more of them, and the seed pods do not shatter, so that good yields are assured.

Wisconsin Lakes is the name of a new pepper that has been developed at the Wisconsin station. This variety has yielded nearly 11 tons of U. S. No. 1 peppers per acre at Hancock, Wis.—93.5 percent of the crop harvested. Wisconsin Lakes appears particularly promising for northern growing conditions where cool weather and moist, highly fertile soil can hamper materially fruit setting on many popular pepper varieties. Seed will be available for commercial production in the spring of 1954.

A new high-yielding summer squash named Storrs Green Hybrid has been reported from the Storrs station (Connecticut). The fruit is of uniform shape and green color. The plant is medium size and open, thus permitting sunlight to give uniformly colored fruit.

The New Jersey station has announced a new sweet corn hybrid, New Jersey No. 106. It matures 4 to 5 days earlier than New Jersey hybrid No. 101, reported last year, which gives it an earliness equivalent to the well-known variety Marcross. Its ears, however, average 1 inch longer than Marcross. New Jersey No. 106 has out-produced Marcross in marketable ears by 29 percent.

Wisconsin Golden 900 and Wisconsin Golden 950 are being released in the summer of 1953 as two superior varieties of sweet corn from the Wisconsin station. Wisconsin Golden 900 is an early canning and market garden hybrid. It produces excellent 12-rowed ears that mature 4 days earlier than Golden Cross Bantam. Wisconsin Golden 950 is a midseason canning variety that is particularly suited for mechanical harvesting.

The continuing high demand for tomatoes and tomato products has resulted in several new varieties. At the California station the variety Simi has been announced. Named after a town in Ventura County, this variety is said to be resistant to verticillium and fusarium

wilts in California. The plants are open and indeterminate while the fruits are oblate and have a deep red flesh. They appeal particularly to the processors of paste and puree in Southern California.

In Florida a new tomato variety named Manalucie has been released. Manalucie will produce successful crops on disease-infested land where no other variety will be successful. It is resistant to fusarium wilt, gray leafspot, early blight (soreshank and collar rot caused by the same fungus), and leaf mold. It is fairly late, with a yield interval corresponding to Rutgers. In Florida it is best suited for a spring crop. The fruit is one that could be harvested in the South in the early pink stage and still reach the Northern market as a sound fruit.

Chesapeake is the name given to a new tomato variety announced by the Maryland station. It is a 3-way cross of Brown's Special, Marglobe, and Pan America. High resistance to fusarium wilt and freedom from cracking are two of its attributes.

Waltham Mold-Proof Forcing is the latest tomato variety introduced by the Massachusetts station in its 20-year effort to combat the tomato leaf mold disease. This disease has long been a problem to growers of tomatoes under glass and the new variety is reported to be entirely immune to it and to be commercially acceptable.

A limited supply of seed of Kopiah tomato was available for 1953. This new variety, developed at Mississippi's Truck Crops Branch Station, is said to be suitable for shipping, processing, and for use in the home garden. It produces a heavy yield on a stocky, vigorous plant. It has outyielded Rutgers and was 3 days earlier under tests at Crystal Springs.

The New Hampshire and North Dakota stations have jointly introduced a new tomato variety—Doublerich. The asorbic acid content of this new variety is noteworthy, and it is of interest to breeders because it is high in vitamin C. It is reported to be crack-resistant and about the size of Valiant.

For those who desire a tomato earlier than Valiant, the New York (Cornell) station has a new one named Valnorth. It is a true-breeding variety, resulting from a cross between Valiant and Farthest North.

Redtop is the name given a new paste tomato from the New York State station. It is a high yielder and the fruits ripen uniformly without green shoulders. They are plum shape with a deep red color.

The U. S. Department of Agriculture and the Utah station have jointly introduced two new verticillium wilt-resistant tomatoes. These are Loran Blood and VR Moscow. In sections of Utah where verticillium wilt has been prevalent, better canning crops are anticipated through the development of these two new varieties. Loran Blood is a Stone cross that is earlier and yields about 20 percent higher than its parent. VR Moscow appears to be the same as its prototype except that it is resistant to verticillium wilt. These two varieties are the result of more than 20 years of effort by breeders at the Utah station.

Calhoun Sweet has been released by the Louisiana station as a new wilt-resistant watermelon variety, resistant even when grown in wilt-infested soil. On one trial this variety produced 1,252 melons per acre, weighing over 20 pounds each, with an average weight of 26.9 pounds per melon. It appears particularly suited to the climate and soil in Louisiana and has shown good resistance to drought.

Rhode Island Red is a new watermelon that is particularly promis-

ing for the Northern States, since it matures in 90 days. It has been announced by the Rhode Island station as a variety that weighs 8 to 15 pounds, is slightly elongated and striped, and has a firm rind and flesh that is of high quality and a clear red color.

Culture of Vegetable Crops

Ways and means of securing more efficient production of vegetable crops are being constantly sought in State experiment station research. Supplemental irrigation is one phase that is currently being given much attention. This is true even in States where the average annual rainfall is usually considered adequate to mature vegetable crops successfully. Experiments at the Mississippi station have shown that irrigation pays in two ways with vegetable crops: (1) It insures early planting and maturing at the optimum time for marketing, and (2) it carries crops through damaging periods of temporary drought. Crop response, costs, and returns have been included in the study at the Mississippi station for a number of vegetables, including tomatoes, sweetpotatoes, bush snap beans, sweet corn, and others particularly suited for fall growing.

At the Utah station the results of a study of the relationship of irrigation and fertilizers to yields of sweet corn have been reported. Increasing amounts of both moisture and nitrogen hastened maturity and increased the yield of stover and ears as well as the size and number of ears. It was also found that sweet corn did not remove measurable amounts of soil moisture below the 36-inch depth.

The Florida station which is continuing its research with the irrigation of vegetables, found that the yield of marketable grades of tomatoes was significantly increased by the use of irrigation. Two side dressings of nitrate of soda at 200 pounds per acre did not increase the yield of marketable fruit; and watermelons did not give increased yields when grown under irrigation or when given a side dressing of nitrogen. This result was obtained during a season when over 14 inches of rainfall were recorded during the growing season.

Supplemental irrigation studies at the Missouri station with various vegetables demonstrate that, in a year of adverse rainfall in southeastern Missouri, yields can be greatly increased by irrigation. Spectacular increases over the check plots were realized for irrigated beans, cucumbers, and sweetpotatoes, which could spell the difference between crop success and failure in dry seasons.

The Arkansas station has found that, by applying 1 acre-inch of water every week to a fall planting of snap beans, the yield was increased 80 bushels per acre over beans not irrigated.

The optimum spacing for vegetable crops is another phase of current research that is pointing the way to a more efficient agriculture. The Rhode Island station has completed a study on the interrelation of plant spacing, rate of fertilization, and variety, on the yield and ear size of sweet corn. The California station reports that maximum yields of green lima beans for freezing are obtained when the plants are spaced about 4 inches apart.

The New York State station has shown graphically that 14,500 plants of sweet corn per acre is the most desirable stand of the larger-growing sweet corn varieties used for processing. To secure the optumum yield this station recommends that corn be planted on a

basis of the number of viable kernels of seed per pound rather than on the basis of a given number of pounds of seed per acre. This station has also recently determined the correct spacing of peas grown for processing. About 20 seeds to the yard of row was found to give the largest net returns per acre of peas grown.

ORNAMENTAL PLANT RESEARCH

Recent ornamental plant research at the State experiment stations has been directed mostly toward floriculture, particularly with those flowering crops that are grown under glass. At the New Jersey station flower production as well as quality was affected when roses growing in greenhouse benches in sand were supplied with boron additives in the nutrient solution. Under normal conditions a value of 0.25 p. p. m. of available boron in the substrate was found to be the most effective concentration for a favorable response. The Mississippi station in research on the propagation of camellias has shown that potted plants are superior to bare-rooted understock in the grafting of small camellias.

Success with the exportation of anthuriums into the United States has led the Hawaii station to study the potentialities of this crop. A study of flower yield has indicated that there is an inherent variability of from 4.1 to 7 in different plants. Plants with high-yielding quality flowers are now being used in a breeding program.

At the Alabama station fertilizer studies with gladiolus are in progress. Fertilizer applied early in the growth of the new plant delayed production, indicating that feeding should be delayed until growth of the corms is under way.

Greenhouse rose culture has long been studied at the Ohio station. Recent reports show that negative results were obtained in an attempt to influence blind wood production by varying the nutritional level of the medium in which the rose plants are growing. The minimum level of nutrition that will give the most profitable production in commercial plantings is recommended.

At the California station a study of the spacing of rose plants to obtain the most profitable number of cut flowers gave interesting results in the first year of a 3-year test. Roses spaced 17,000 plants per acre produced for the first year only one-half the value of those spaced 51,500 plants per acre. The returns from the two methods of planting were $42,000 and $70,000, respectively, and the cost of the additional plants for the closer spacing $1,200.

Improved cultural methods for growing greenhouse hydrangeas have been developed at the Maryland station. Applications of nitrogen fertilizer during the forcing season resulted in an increase of pink flowers. Under phosphorus fertilization plants produced pinker flowers but only when nitrogen had also been applied. Potassium fertilization resulted in a bluer flower color.

The New York (Cornell) station has established conditions under which a number of cut flowers will keep most satisfactorily in storage. Carnations, pompom chrysanthemum, roses, lily-of-the-valley, and garden lilies stored most successfully, and injury from mold was least, at temperatures of 31° F. Flowers stored in a dry condition and wrapped in moisture-proof packages were generally superior to those stored at the same temperatures with their stems in water.

At the Michigan station a breeding program with snapdragons has been under way since 1949. From this have come two new varieties of snapdragons. Spartan Rose is an extremely vigorous and productive variety with a noteworthy tolerance to warm weather. It has bright attractive rose colored flowers. Spartan White approaches perfection in the desirable shape of its flower spikes. Clubbiness of spikes is not a problem even in the darker days of midwinter. It bears pure white flowers that exhibit a remarkable resistance to shattering. Both varieties should be generally available by the spring of 1954.

FRUIT PRODUCTION RESEARCH

Fruit production research represents one of the oldest phases of agricultural research. Because of the relatively slow growth of plant materials with which horticulturists work, research often takes years before it is completed. Each year brings outstanding advances, however. A station may announce the development and breeding of a new fruit variety to meet special requirements or it may introduce improved practices that will result in a net gain to American fruit growers through more efficient production.

Chemical Thinning of Fruits

Chemical thinning is of considerable advantage to fruitgrowers faced with high production costs and a shortage of competent laborers.

Research at the Missouri station indicated that the use of a fruit-thinning substance such as NAA (naphthaleneacetic acid), produces two significant and opposing physiological effects. These are (1) a temporary retardation in the separation of cells along the abscission zone of the pedicel, and (2) a strong and prolonged inhibition of embryo development. The station suggests that the relationship between these two influences has a direct bearing on the extent to which induced fruit thinning should be carried out, and that the inhibition of embryo function and development is by far the more important and deciding factor. The temperatures prevailing during the fruit-setting period influence the duration of the effect of the fruit-thinning chemicals. In cool weather, the effective period may be 3 weeks as compared with the usual 10 days to 2 weeks in warmer weather.

According to the Pennsylvania station, one of the important advantages from chemical thinning of apples is the increased percentage of the crop that will grade out into the larger and more profitable sizes. Generally an increase in the concentration of a thinning chemical such as NAA resulted in greater thinning of the fruit. Yields were more satisfactory when the NAA sprays was applied 22 days after calyx time than at 13 or 18 days.

From tests of the effects of several chemicals in the thinning of fruit, the Massachusetts station concluded that the nitrogen status of an apple tree may be an important factor in certain varieties in determining the degree of thinning obtained with thinning chemicals. The station observed that the use of chemical thinning agents is valuable in inducing annual fruiting and a biennial fruiting tendency in apple varities.

As reported by the Ohio station, weather conditions prevailing at the time of fruit setting have a considerable influence on the effective-

ness of fruit thinning sprays. Under conditions highly favorable to successful pollination, higher concentrations of NAA were needed to adequately thin the fruit of apple trees than were ordinarily expected. Concentrations of 40 and 60 parts per million (p. p. m.) of NAA applied 18 and 26 days, respectively, after full bloom, thinned the young fruits more satisfactorily than did concentrations of 10 and 15 p. p. m. applied at full bloom and petal-fall, respectively.

Further evidence that proper timing of chemical sprays used in fruit thinning is very important was presented by the Maryland station. Concentrations of NAA that gave good results when applied 16 to 24 days after full bloom to York and Stayman apple trees proved inadequate when applied earlier. NAA has proved so promising in station investigation as an apple-thinning agent that the station estimated that Maryland growers would treat between 2,000 and 3,000 apple trees with NAA in the spring of 1953. None of four chemical thinners tested by the Maryland station had any harmful effect on the cracking of Stayman apples.

Further evidence that NAA is gaining wide favor as a thinning agent for apples is shown in a statement from the Michigan station that nearly one-half of all the commercial growers in the State use this chemical for thinning fruit.

The Idaho station explored the use of chemical sprays for thinning of peach flowers and fruit. Elgetol (sodium dinitro-ortho cresolate) appeared impractical because the amount of bloom varied widely among different trees in a single orchard. NAA applied 4 weeks after bloom resulted in fair to good thinning, but the optimum concentration of the chemical varied with varieties.

Late Elberta was thinned satisfactorily at a considerably lower concentration than J. H. Hale or Rio Oso Gem peaches. Because of these variable responses the station was not able to issue any general recommendations to peach growers.

Of two chemicals—maleic hydrazide and 2,4,5-trichlorophenoxyacetic acid—tested by the Florida station for thinning pecans, the latter gave good results with the Moneymaker variety. Where heavy thinning occurred nut weight was increased about 10 percent, but the percentage of kernel was not improved.

New Fruits

No subject has more universal interest to fruitgrowers than new varieties. This is understandable, particularly with tree fruits for which no returns are received for several years. Only the best of varieties should be planted and, even then, there is a chance that better new kinds may appear in the interval between setting the trees and the production of fruit. A few examples of recent fruit introductions are presented.

The Crandall apple, developed by the Illinois station from a cross between Rome Beauty and Jonathan and introduced to the public in 1952, is a red winter-type apple desirable for dessert and cooking.

Commercially acceptable apples with immunity to the apple scab fungus is the goal of a cooperative study by the Illinois, Indiana, and New Jersey stations. A modified backcross program is being followed to combine the scab resistance of certain small-fruited apple species with the desirable horticultural characters of commercial vari-

eties. Several selections from the most advanced breeding lines are approaching commercial size. Further backcrossing will be pursued to gain more size and better quality.

New Japanese-type plums, Burmosa and Redheart, originated at Davis, Calif., under a fruit-breeding program by the California station (coop. USDA) promise to be valuable additions to the California list of plums acceptable for eastern shipment. Both are large-fruited, red plums of attractive appearance when fully mature.

Golden West, a yellow-fruited raspberry, originated in the small fruit breeding program of the Washington station carried on at Puyallup, is a desirable novelty for the home garden and possibly for local fresh fruit markets. Golden West came from a cross of two red raspberries, Cuthbert and Lloyd George. The new yellow berry is more productive and less susceptible to disease than any other yellow raspberry growing at Puyallup and yields a good flavored product when canned or frozen.

The Mysore raspberry originally came from India and reached Florida in the summer of 1948, where the Florida station found it to be well adapted to the soils and climate of the southern part of the State. Previous to the introduction of Mysore, no raspberry could be grown successfully in that section. The fruit resembles the northern black raspberry in general appearance but is dark purple in color when fully matured. Ripening occurs over a period of several months, reaching a peak from March to May.

The Early Red raspberry, originated and named by the Michigan station, was obtained from a cross of Lloyd George by Cuthbert and in general appearance resembles more closely the Cuthbert parent. Earliness combined with good horticultural qualities makes Early Red a valuable addition to the raspberry list.

Two new blueberries, Angola and Ivanhoe, developed by the North Carolina station (coop. USDA) provide growers in North Carolina and nearby areas with desirable canker-resistant varieties. Angola is described as highly resistant to canker and Ivanhoe as tolerant to this serious trouble. Both blueberries possess desirable horticultural characters such as good size and flavor and an attractive appearance.

Keweenaw blueberry, bred by the Michigan station and introduced in 1952, is recommended for trial planting in northern Michigan in places near the lakes where the growing season is at least 145 days in length. Keweenaw originated as an open-pollinated seedling of Katherine, which it resembles in the fruit.

The Albritton strawberry, originated by the North Carolina station (coop. USDA) was selected as a promising commercial variety for North Carolina because of its high yield of good quality, attractive berries. In a test in 1951 at Willard, N. C., Albritton yielded 360 crates per acre as compared with 280 for Massey and 188 crates for Missionary. Albritton is attractive in color, firm in texture, and good to excellent in flavor—all of which combine to make the new variety a desirable market and shipping berry.

The Plentiful strawberry released by the Illinois station in the spring of 1953 came from a cross of Redstar and Pathfinder. The variety is resistant to red stele, leaf spot, and leaf scorch—three serious diseases of the strawberry—and, in addition, possesses good horticultural qualities that make it a desirable market and home garden berry.

Eden, a new strawberry originated by the New York State station from a cross of Dresden × Fairfax is described as particularly desirable for freezing, canning, and preserving, and as having flavor a little too tart for fresh dessert use.

A new walnut of the Persian or English type was introduced by the Illinois station in 1952 under the name of Colby. It was grown from an open-pollinated seed of Crath 10. This variety has two good qualities: It matures early and shells are thin and contain well-filled kernels of good flavor.

Cultural Problems

Various State stations and the U. S. Department of Agriculture are concerned with the failure or poor growth of peach trees when planted on sites from which old peach trees have been removed. Among State stations that are studying this problem are California, Georgia, North Carolina, and New Jersey, all important peach-producing States.

What may be a very important development in the replant problem is the discovery and identification by the Georgia station of a fungus, *Clitocybe tabescens*, which was found in many peach-growing areas of Georgia and South Carolina. Because of the presence of this root rot on the roots of dead and dying peach trees in many different orchards where second and third plantings of peaches had been made on old orchard sites, it is believed that the organism is the primary cause of severe losses in many such situations. No apparent relationship could be established between nutrition or toxicities and the loss of trees, nor could any difference in susceptibility be noted whether the trees were budded on Shalil, Yunnan, or Tennessee Natural rootstocks. A practical suggestion was to avoid planting peach trees on old peach sites or on newly cleared forest land.

A different approach is being made to the peach replant problem at the California station where the soil has been treated with different chemicals, such as carbon bisulphide and DD, prior to replanting peach trees. In the early stages, no significant difference has been observed in the growth of replants on the various plots. There is a definite possibility that there are different causes for the failure of replanted peach trees in different parts of the country.

In New Jersey where the establishment of peach orchards on sites from which old peach trees have been removed is often difficult, especially on the more sandy soils, some evidence was obtained that soil fumigation may be helpful. It was concluded that a reduction in nematode population may help. In an orchard near Vineland, where 22 percent of the newly planted peach trees failed to survive the first growing season on the untreated plots, all trees that received soil fumigation and corncob mulch survived. Benefit may have resulted from the corncob mulch because of improved soil moisture conditions.

Productivity of vineyards was found by the Missouri station to be correlated with the quantity of available phosphorus in the top 6 inches of soil. Vineyards on soil with a content of 200 pounds or more of available phosphorus yielded 6 to 7 tons of grapes per acre. Yields decreased with lessened amounts of available phosphorus in the soil. Where the phosphorus level reached 10 pounds or less, yields were usually less than 1½ tons of fruit per acre. No definite relationship

was established between yield and available magnesium, calcium, and potassium in the soil. These did not vary greatly in the several vineyards under study. Soil acidity was about pH 6.3 in the more productive and about 4.6 in the low productive vineyards.

Ohio experiments indicate that the beneficial effects that may accrue to apple trees from foliar sprays of a nitrogenous material, such as urea, may be closely related to the nitrogen status of the trees. Increased yields resulted from the application of foliage sprays to Jonathan apple trees which had received no nitrogen the preceding year, but when the spray was applied to trees to which urea had been applied the preceding year, actual reductions in yield were recorded.

Studies by the West Virginia station showed that the terminal growth of apple trees was benefited to little or no extent as a result of foliar sprays of nitrogen. Variation in yields both within and between treatments were such as to permit no deductions with respect to their effect on yield. Some evidence of foliage injury was seen on certain of the nitrogen-sprayed trees.

Based on long-continued studies in peach orchards in different parts of the State, certain practical suggestions were presented by the Arkansas station for reducing losses from winter injury. Culture and fertilization should be such as to favor rapid early growth; later it should be sufficient to maintain the trees in full foliage throughout the summer and fall. Heavy crops should be thinned to reduce the drain on the trees. Late fall applications of nitrogen should be avoided, including application of nitrogen to legume cover crops. Such a program is said to increase the carbohydrate accumulation in the tree, which in turn influences greatly the intensity of the rest period and resistance of both wood and buds to winter injury.

As reported by the Ohio station the mulching of red raspberries is a desirable cultural practice. Both total yield and size of individual berries were materially increased in the mulched plots. Nitrogen, used alone, had no effect on berry size or upon cane development. An average of 2-year-records indicates that mulching may increase acre yields by 500 to 600 pints, or about 12 to 15 percent.

BETTER FARM FORESTS

The present high price of lumber and lumber products has made the American farmer conscious of the potential value of his woodlands and more interested in their efficient management and utilization. Increased emphasis on these phases of forestry research is reported by the stations.

Fire control and prevention of insect and plant disease damage are also becoming increasingly important as woodland values rise.

Studies of growth in spaced pine plantings, led the Georgia station to conclude that in general the closer plantings such as 4 x 4 feet, yielded the largest total cubic foot volume per acre. By contrast wide spacings such as 12 x 12 feet produced the smallest total cubic feet. Spacings of 6 x 6, 6 x 8, and 8 x 8 feet, respectively, for loblolly, slash, and shortleaf pines appeared most desirable in order to obtain the largest total merchantable volume per acre.

Microdendrometer measurements by the Illinois station of the diameter growth of shortleaf pine and white oak trees, showed that there is considerable fluctuation in both species when the soil moisture situa-

tion reaches a critical point. Diameter increased when there was available moisture and decreased when moisture became unavailable in the top 1.5 to 3.0 inches of soil.

The possibility of speeding up the growth of loblolly pines by fertilization was investigated by the North Carolina station in 6-, 9-, 12-, and 16-year-old plantings located in the Hill Demonstration Forest in Durham County. Thirteen different fertilizer treatments involving several rates and combinations of ammonium nitrate, treble superphosphate, and muriate of potash were applied in replicated plots. One year after fertilization, a tendency was noted toward greater height and diameter in trees on the heavier fertilized nitrogen and phosphate plots, but differences were not significant. Broadcasting of the fertilizer was apparently as effective as hole placement. Nitrogen content was higher in needles of trees receiving nitrogen than in needles of trees receiving only phosphorus and potash fertilizer.

The value of thinning dense stands of young Virginia pine was shown by the Pennsylvania station. In 1942 an 8-year-old stand containing 3,000 to 3,400 trees was thinned to about 420 crop trees per acre. Measurements 11 years later showed 240 trees of 5-inch diameter at breast height in the thinned area as compared with 70 in the unthinned area. There were, however, sufficient trees of 4 inches or more in diameter in the unthinned plot to provide enough crop trees to stock a normal stand at 50 years of age.

The importance of careful site selection for forest tree plantings was stressed by the New York (Cornell) station. Records taken in two southern counties showed that there was less than 50 percent survival of planted trees. Red pine in particular suffered greatly on poorly drained soils. Site evaluation can be aided by use of soil maps as well as by a more careful examination of the soil.

That the manufacture of charcoal may provide a satisfactory outlet for the disposal of inferior material obtained in improvement cuttings, thinnings, etc., is suggested by the Vermont station. The gross return per man-hour of labor in charcoal production was $1.55 in both 1951 and 1952 operations. A reasonable charge for the wood entered into the computation. Charcoal derived from wood cut the preceding spring was more solid than that from wood cut 2 years in advance of need.

PLANT DISEASE INVESTIGATIONS

Agricultural research is concerned with the life sciences in their most fundamental aspects. Especially is this true in plant pathology. Although the plant pathology departments of experiment stations are making satisfactory progress in developing practical methods for the control of plant diseases, it must be kept in mind that much of this progress has grown out of fundamental research. Many important crops, such as wheat, potatoes, sugarcane, and fruits, could not be grown at their present rate if it were not for the economic control of the more devastating diseases by crop rotation, breeding, and chemicals.

Plant pathologists generally direct their attention to the practical farm problems first. But they must be concerned constantly with such basic questions as: Why is one strain or plant resistant, whereas others are susceptible to certain disease organisms; why do some fungicides

kill the organisms while others do not; how do the multitudes of viruses, bacteria, and fungi affect plant cells; why are some destructive and others harmless? To conduct fundamental research of this nature requires well-trained scientists. The science of plant pathology as carried on at State agricultural experiment stations provides excellent opportunities for sound research as is revealed by the subsequent examples of recently reported research.

Disease Resistance in Plants

Studies at the Wisconsin station on the nature of fusarium wilt in tomato have shown that the disease is initiated by the enzyme, pectinase, produced by the fungus that caused the plants to wilt and sap vessels to turn brown. Pectinase is the enzyme that breaks pectin cell wall materials into sugar within the plant. The resistant character was shown to be distributed throughout the plant and not confined to the root system as earlier studies indicated. Why one plant is resistant and another susceptible is still unknown, but as facts are gradually uncovered, an answer will be forthcoming.

In seeking the reasons why some potatoes are susceptible and others resistant to the ring rot bacterium, the North Dakota station found that the susceptible Triumph potato stem was comparatively rich in the amino acid proline, but contained only traces of asparagine. The opposite was true for the highly resistant plants. In addition to these significant differences, the resistant plant had a greater concentration of the amino acids. If a plant's resistance to a disease organism can be explained on this basis, the development of resistant varieties may be facilitated.

The difference between scab-resistant and scab-susceptible potatoes is only skin deep, according to recent research at the Wisconsin station. Some outside cells of the skin die as a potato gets bigger. These cells are shed from the skin of resistant varieties, but cling to the surface of susceptible varieties. When the dead skin gets several layers thick and breaks up into irregular masses, the scab organism evidently finds a home. This research has yielded what may be an easier way to test seedlings for scab resistance. A quick and simple microscopic test would take the place of a generation of potatoes grown in the greenhouse and selected for scab resistance. In this connection, the Colorado station (coop. USDA) found that the amount of chlorogenic acid present in the skin of the potato tuber determines its resistance to the scab fungus *Streptomyces scabies*. Tubers from a highly scab resistant potato seedling contained 77 mg. of chlorogenic acid per 100 grams of peelings, whereas, a susceptible seedling contained only 40 mg. chlorogenic acid per 100 grams of peelings.

Diseases of Field Crops

Cereal diseases

Yellow-dwarf, a comparatively new and damaging virus disease of cereals, occurred over wide areas in California in 1951. The disease causes leaf yellowing in barley, leaf reddening and head blasting in oats, and a chlorosis in wheat. Moderate to severe stunting occurs in all three cereals. The California station has shown that the disease is caused by a virus and that it is readily transmitted by five species

of aphids, *Macrosiphum granarium*, *M. dirhodum*, *Rhopalosiphum maidis*, *R. prunifoliae*, and *Toxoptera graminum*. Tests have shown that the yellow-dwarf virus attacked 55 grasses which may furnish a constant supply of the virus for aphids to transmit to the small grains. The disease is expected to bring serious problems in California during years when climatic conditions delay planting of grain until March and at the same time are favorable to aphid reproduction and the growth of susceptible wild grasses.

What may turn out to be a closely related virus was found by the Minnesota station to cause the blue-dwarf and red leaf disease of oats. The virus nature and aphid transmission of red leaf seems certain, and that of the blue dwarf probable. Neither disease was studied in the absence of the other. It was not possible to transmit these diseases manually.

Wheat streak mosaic was first found in Kansas in 1932. Although the disease recently damaged wheat crops in several States in the Great Plains region, it had never been understood how the virus could spread so rapidly from plant to plant and field to field. Research started at the South Dakota station and concluded at the Lethbridge station in Canada has revealed the answer to a perplexing problem. It has now been shown that the wheat streak mosaic virus is transmitted by a tiny mite in the genus *Aceria*. The vector is so small that cages made of 112-mesh sheer nylon proved ineffective in excluding the mite and protecting the pot-grown wheat plants from becoming infected. These results were further confirmed by the Nebraska station. The disease can be successfully controlled in Nebraska by planting wheat in the late fall and by eliminating sources of infection such as volunteer wheat and grass weeds. The Nebraska station studies also disclosed that there are probably nine or more virus entities that may cause various wheat mosaics. The virus complex in cereals appears to be much more intricate than heretofore supposed.

Cereal rusts

Basic work on the nature and behavior of cereal rusts at the Minnesota station helps the plant breeder to produce and maintain resistance in varieties of small grains. The rust situation is continually changing and new races threaten previously resistant grain varieties.

Race 15B is now the predominant wheat stem rust strain in the United States, comprising over 58 percent of the 1,279 isolates made in 1952. It now occurs throughout the United States, except the Pacific Coast States, and in the principal wheat-growing areas of Mexico. Of special interest was the occurrence of races 11, 49, and 139 that heavily attack, under a wide range of conditions, some varieties and breeding lines that are resistant to 15B.

Surveys made in 1953 revealed that all the durum wheats are more susceptible to race 15B of stem rust than the bread wheats. Because the durums mature 3 to 5 days later than the bread wheats, they are subjected to rust infection longer and are more severely injured. Survey data show that the durum wheats suffered severe losses in North Dakota, South Dakota, and Minnesota in 1953.

Leaf rust of wheat

Basic information on the reaction of different wheat varieties to the various races of leaf rust is being obtained at the Kansas and Oklahoma stations that will enable plant breeders to avoid parent strains having undesirable susceptibility. For example, in 1952 Oklahoma plant pathologists found two new biotypes of leaf rust race 105 which attack varieties whose ancestry include Hard Federation, commonly used in wheat breeding. Field surveys have shown that there is a definite relationship between an increased acreage of a variety and the number of rust races to which it is susceptible. For example, recent extensive planting of Triumph has resulted in an increase in rust race 15, to which Triumph seems especially susceptible in the field.

Promising fungicides for rust control

For many years the only practical methods advocated for the control of stem rust have been the breeding of highly rust-resistant varieties and the elimination of the rust-spreading barberry. Now, however, it is hoped that some of the new fungicides that are being developed for the control of plant diseases, may provide an effective medium for reducing rust losses. Rust-preventing fungicides would be highly desirable in emergencies when there would not be time to develop the resistant varieties or to eliminate the rust-spreading barberry.

The Wisconsin station found that certain naphthoquinones and phenols have shown fungicidal value at low concentrations. The germination of urediospores of the stem rust fungus was prevented at concentrations as low as 2 p. p. m. Spray applications made prior to infection, in which the fungicide was used with a spreader and stabilizer, resulted in 90 to 100 percent rust control for several compounds studied. Ethyl-alcohol solutions of technical 2,3-dichloro-1,4-naphthoquinone (Phygon) with a stabilizer appears to be the most economical compound presently available.

Calcium sulfamate and Actidione promise to become effective systemic fungicides for the control of stem and leaf rust in wheat, according to research under way at the Nebraska station. These chemicals were found suitable for aerial application at volume rates as low as 5 gallons per acre. They proved effective in stopping development of the rusts even after infection had occurred. Although calcium sulfamate and Actidione induced physiological changes in the plant, so far they have not been found to be detrimental.

Smut increases in Northwest

According to an Idaho station report covered smut of wheat is on the increase in the Pacific Northwest in spite of the combined efforts of growers and experiment station and extension workers to combat it. The survey showed that 27.8 percent of the total crop of 88 million bushels of wheat graded smutty—an increase of 3.9 percent over the 1951 figure of 23.9 percent. The estimated regional loss caused by smut in 1952 was over 6 million dollars. One of the reasons given for the increase in smut is that new races of the smut fungus arise that are able to attack varieties formerly considered resistant.

The Washington station (coop. USDA) has shown ways whereby these new smut races are produced. It demonstrated for the first

time that there is fusion between secondary sporidia (spores) in culture. Unique relationships were exhibited in matings between primary and secondary sporidia. In some case monosporidial lines of opposite sex, as indicated by fusion between secondary sporidia, were not completely opposite in their relationships with primary sporidia, as shown by fusion between primary and secondary sporidia. It was also found that the host range and different degrees of virulence of a particular host are not necessarily measures of heterozygosity or homozygosity in races of this species. A homozygous condition was found in one race having a wide host range. On the other hand, a race with a narrow host range and low degree of virulence on one variety was found to be heterozygous for pathogenicity. This study emphasizes the complexity of the smut problem and supports earlier speculation on the potential instability of chlamydospore populations designated as races.

Oat soil fungus inhibits cereal seedling blight

Plant pathologists at the Ohio station have come up with another example of nature's checks and balances in demonstrating that certain fungi in oat soils reduce seedling blight in corn subsequently planted in oat soil. They have established that *Aspergillus*, a fungus occurring in oat soil, is antibiotic to a cereal blight organism that retards growth of corn and wheat. When molds from oat soil were mixed with a seedling blight fungus in sterile soil, seedling blight of corn was reduced from 89 percent to 8 percent. Seedling blight of wheat was half as prevalent in oat soil as it was in either corn or wheat soil. With corn grown on oat soil, a third less of the plants were infected with the blight organisms than was true when corn was seeded in corn or wheat soil. Corn plants in oat soil were more vigorous, taller, and had healthier, more abundant roots than corn grown on wheat or corn soil.

Root rot of barley

Root rot is rapidly becoming a limiting factor in the successful production of barley in South Dakota and in other States that raise this crop. Heretofore, barley varieties or strains that possessed resistance to any appreciable degree to common root rot were not known.

The South Dakota station (coop. USDA) tested several thousand varieties of barley which had been collected throughout the world. In 1952 certain of these varieties and lines were planted in Tripp, Douglas, and Brookings counties. The data obtained from Tripp County, where root rot is more severe, indicated that a number of barleys possessed high resistance to the root rot complex. As a group, those obtained from Manchuria seemed to stand out in this respect.

Leaf area affects stalk rot in corn

It has been known that loss of leaf area increases the susceptibility of corn plants to damage by diplodia stalk rot. A similar effect has now been demonstrated by the Illinois station for *Gibberella zeae* stalk rot. Reducing the leaf area by clipping brought about premature death of plants and stalk breaking, the increase in susceptibility

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to stalk rot being least in the checks, significantly higher in plots inoculated with *Gibberella*, and highest in plots inoculated with *Diplodia*. A striking result was the development of natural gibberella rot infections at above-ground nodes in 75 percent of the plants with clipped leaves, compared to only 17.3 percent of such infections in plants with normal leaves.

Tobacco diseases

A histological study of tobacco black shank infections, reported by the North Carolina station, has shown that the causal organism (*Phytophthora parasitica* var. *nicotianae*) freely penetrates the roots of both susceptible (402) and resistant (Dixie Bright 101 and Dixie Bright 102) varieties. In the susceptible variety the pathogen rapidly ramifies through living host cells and colonizes abundantly in the invaded tissues. Impoverishment of the parasitized host cells quickly follows, resulting in the depletion of their contents. Invasion by the fungus continues until the entire root system is destroyed and the plant dies. In the resistant varieties, however, the epidermal cell entered by the fungus and those adjacent to it suddenly died and collapsed. Owing to this hypersensitive host cell response, the invading pathogen makes only slow, feeble growth and often fails to become established. It was found that this hypersensitive response was characteristic only of epidermal and cortical tissues of resistant roots and that, if the pathogen were in some way introduced into the pith or vascular system of such roots, pathogenesis would proceed in a manner similar to that noted in susceptible plants. This may explain how root injuries caused by parasitic nematodes or other agents may predispose resistant plants to black shank and increase the incidence of the disease in resistant varieties.

The Virginia station found that soil fumigation and rotation reduce pathogenic nematodes and give greater returns from the black shank resistant varieties. It was also observed that moderately resistant varieties with more desirable qualities can be used if the soil is fumigated, or in a rotation.

The Virginia station estimates that in 1952 the tobacco growers in the State lost over 12 million dollars from tobacco diseases. Black shank caused the heaviest loss, estimated at over 5 million dollars, and root knot nematode caused damage amounting to over 4 million dollars. The value of the State tobacco crop, all types, was nearly 85 million dollars.

The Connecticut Agricultural Experiment Station (New Haven) discovered that downy mildew of tobacco seemed to get started from local sources of inoculum. The mycelium and conidia (spores) of the mildew fungus overwinter on old tobacco leaves and provide a local source of inoculum in the ensuing year.

Sugarcane mosaic

Experiments at the Puerto Rico University station did not confirm the general farmer belief that the mosaic-susceptible sugarcane variety B. 34–104 could produce more sugar than the currently known commercial varieties, and that this variety recovers from the disease. Once the canes of B. 34–104 were infected with the common sugarcane mosaic prevailing in the Island, they did not recover from the disease

and the infected seed produced infected plants. The tonnage in the plant cane crop was reduced 29 percent, and 32 percent in the first ratoon crop because of mosaic. There was also a reduction of 26.7 percent in the production of 96° sugar per acre in the plant cane crop, and of 41.7 percent in the first ratoon crop. It was concluded that if B. 34–104 could be maintained free of mosaic, it would produce about the same quantity of sugar as P. O. J. 2878, but a greater tonnage would have to be handled and processed, and profits would be lower.

Diseases of Forage Crops

Blackstem reduces seed yield in alfalfa

Blackstem, caused by the fungus *Ascochyta imperfecta*, is one of the most destructive diseases of alfalfa. It attacks all parts of the plants, including the inflorescence, where, according to the Minnesota station, it is particularly destructive to the seed. Seed loss was found to be proportional to the amount of the disease and infestation of viable seeds was directly related to the amount of seed loss. Seed loss in commercial fields ranged from 2 percent where there was little black stem, to 28 percent in severely infested fields, and the infestation of viable seed ranged from 16 to 24 percent in the same fields. Alfalfa seed from severely infected fields weighed only 35 pounds per bushel, whereas 60 pounds per bushel is normal seed weight.

Chemical control of crown rot of ladino clover

Crown rot caused by the fungus, *Sclerotinia trifoliorum*, has become increasingly severe in ladino clover during the past 3 years in California. Blocks in a severely and uniformly infested field were sprayed in January 1953, with nine different fungicides. None of the sulfur, copper, organic mercuries, and carbamates used gave any control. The only material found by the California station which suppressed the growth of the fungus was pentachloronitro-benzene (Mathieson 275) used at 9 to 18 pounds of active material per acre and applied either as a spray or dust. This material completely and immediately checked the fungus which did not again become active during its normal period of activity, up to April 1, 1953. The treated areas rapidly recovered after application of the chemical and were dark green in contrast to the light green unsprayed plots. The average dry weight yields of eight paired blocks showed the yield of treated blocks to be 2.8 times that of the untreated.

Ergot-resistant strains of Dallis grass

Dallis grass is the most important summer-growing perennial pasture grass in the South. Its past usefulness has been limited by its total susceptibility to ergot and by a limited seed supply. Ergot is a disease that attacks the flowers and replaces the seed with a fungus body, and when present in sufficient quantity, is toxic to livestock. Good progress has been made by the Mississippi station in developing seed-producing and ergot-resistant strains of this grass. Seed yields from seven new lines doubled those of ordinary strains, and herbage yields ranged up to 86 percent greater than common Dallis grass. Mississippi alone requires 1,500,000 pounds of Dallis grass seed an-

nually. This study should make possible more profitable domestic production of such seed and at the same time increase the usefulness of Dallis grass.

Effects of Chemicals on Heridity in Micro-Organisms

Certain simple but highly reactive organic compounds such as betapropiolactone and ketene, the New York (Cornell) station has found, induce permanent alterations of genes and chromosomes. In the mold Neurospora these mutations are manifested as differences in potentiality for the synthesis of vitamins, amino acids, and other compounds important in the nutrition of the organism, and as more or less extreme variations in form and color. An adaptation of techniques has made the initial separation of nutritional variants from standard types relatively easy. Nutritional variants of micro-organisms are widely used for bioassay purposes, and for studies of gene action in relation to the biological synthesis of important cell constituents. Analysis of variants that show extreme differences in form should give an insight into the relationships of heredity, biochemistry, and morphology. One morphological variant that grows in globe-shape rather than as a spreading web, is characterized also by a defect in amino acid metabolism. The finding of new chemical mutagens provides additional tools for the creation of hereditary variants to be utilized by geneticists.

Diseases of Fruits

Studies by the Oregon station during the last 5 years indicate that the mahaleb rootstock is immune from the western X-disease and that the virus will not move through this rootstock. Thus it is possible to topwork mahaleb after it has formed several branches. Each separate branch would then have to be infected with the virus and it will not spread from one branch to another. It might thus be possible to prolong the life of a cherry tree several years even in areas where the spread of the virus is very rapid.

The Pennsylvania station found that the Montmorency sour cherry was an excellent virus indicator plant when used in the greenhouse. When healthy cherry trees were budded from infected sources, symptoms of necrotic ring spot were expressed in from 7 to 20 days, depending upon the greenhouse temperatures. Elberta peach trees budded in the spring before bud-break were not found to be good indicator plants, since in most cases the reactions shown were mild and hard to see; however, there was a high degree of correlation between the sour cherry and the peach indicator plants.

Western X-virus, which has been transmitted to the peach by an insect vector, was transmitted by the Utah station through approach-grafting techniques from infected peaches to sweet and sour cherries on mahaleb rootstocks producing typical wilt and little cherry western X symptoms. It was also found that sour cherry yellows symptoms appeared when necrotic rusty mottle inoculum was placed in sour cherries.

When the cucumber was used as an indicator plant at the Wisconsin station (coop. USDA) to detect the presence of viruses in stone fruits,

it was found necessary to define the optimal ranges of temperature and light intensity for best results. It was also found that a virus could be transmitted mechanically from peach and *Prunus mahaleb* to tobacco and zinnia, as well as cucumber. By the use of dodder, virus was transmitted to five species of herbaceous plants from X-disease *Prunus*. The identity of the viruses transmitted to *Prunus* have not been determined.

Diseases of the low-bush blueberry

Low-bush blueberry production is concentrated in Maine where the berries grow in native uncultivated stands. Little has been known about diseases that affect the low-bush varieties and how to prevent them. The Maine station has surveyed around 1,000 cultures of organisms which might be disease-producing on low-bush blueberries. This work has resulted in establishing eight identifiable diseases, all of which are of economic importance in low-bush culture.

Controls for some of the diseases, particularly twig and blossom blight, have been found, and their use has resulted in increased yields. Use of the control now recommended for twig and blossom blight—a ferbam fungicide applied as a dust—has resulted in abundant crops. The research has shown, however, that there are other benefits from using the ferbam. Whether factors other than control of the disease are responsible for the yield increases is not known. Research is continuing in an effort to establish the effects of ferbam and to develop controls for the other diseases.

Vegetable Diseases

In field tests conducted by the Florida station (coop. USDA), bean seed planted on the same day that a green manure crop was turned under, gave as low as 5 percent stands, whereas almost perfect stands resulted when the seedbeds were prepared 30 to 40 days before planting. Root rots and damping-off of beans were consistently reduced when Mathieson 275 fumigant was applied in the row at planting time. The Idaho station also learned that fumigants applied in the row at planting time at 1 to 1.5 gallons per acre gave excellent control of root rot of peas and beans. The costs of materials and applications were low enough to make fumigation practical on commercial farms.

The wide interest in the use of soil conditioners led the Massachusetts station to see what effect they had on certain plant diseases. Krilium and Aerotil showed no soil fungicidal properties, as they failed to control club root and damping-off of crucifers. They were, however, found useful as carriers of fungicides, and captan and technical dibromabutene applied to the soil in this manner effectively controlled damping-off of vegetables.

Nematode resistance in tomato

The Hawaii station has developed a variety of tomato that is resistant to root knot nematode, a serious pest on most crops in the warmer areas of the world. This variety can be rotated with susceptible crops, for nematodes die out at their normal rate while the crop is growing. After the tomato crop is harvested, the field is ready for a

susceptible crop, because the number of nematodes diminishes for several months before the tomatoes are harvested. This variety of tomato is late and large-fruited, hence is adapted to warmer areas. Crossed with desirable varieties, the F_1 hybrid matures early and produces well, and resists diseases. The new variety is resistant to fusarium wilt, stemphylium leaf spot, and Hawaiian spotted wilt, as well as root knot nematodes.

Tomato yields reduced by virus

Glasshouse crops of tomatoes in Ohio are almost universally infected with the tobacco mosaic virus. Infection of field crops is not as widespread, but the percentage loss per acre is higher. Studies reported by the Ohio station show that the disease may reduce yield from 10 to 25 percent in glasshouses and 10 to 50 percent in field tomatoes. The disease retards the development of the crop approximately 10 days and reduces the grade of the fruit, which results in further losses. The magnitude of the loss caused by the tobacco mosaic disease on tomato justifies the emphasis placed on its control. Where strict sanitary measures are practiced, the effects of the disease are considerably lessened. Use of tobacco, especially cigarettes, around plants may lead to serious infection. Greenhouse help must exercise care in handling diseased plants since the mosaic infection can easily be transferred from one plant to another. Much of the Ohio work has been centered around a plan to learn the conditions which bring about the disease, in order that control measures may be set up.

Regional Research and Disease Control

The Interregional Potato Introduction Station (coop. USDA) at Sturgeon Bay, Wis., is making valuable contributions to potato improvement practices throughout the United States and also in other countries. The recently completed greenhouse and storage plant at the station have resulted in a marked increase and distribution of germ plasm material. Stocks have been received from 14 countries, and shipments from England, Scotland, and Germany are of particular interest and show considerable promise. In 1952, breeding material was shipped by the laboratory to 18 States and 10 foreign countries. Excellent progress is being made in evaluating strains and varieties for resistance to late blight, scab, virus diseases, and insect pests, and tolerance to frost.

Screening wild tomatoes for disease resistance

An example of a large-scale cooperatve effort that has emerged from regional research is the screening and evaluation of wild species of tomato for disease resistance by a volunteer group of plant pathologists. The Primary Plant Introduction Station at Ames, Iowa, operating under a regional agreement between the experiment stations of the North Central Region and the Department, supplied seed of 144 accessions of wild tomatoes to the 45 plant pathologists who cooperated in the work during 1952. They represented experiment stations in 24 States, Hawaii, Canada, and two commercial canning companies. Information was obtained under a wide range of conditions on the resistance of the wild species to 16 separate diseases that

affect the production of commercial tomatoes. Similar tests are being repeated this year and the results will then be assembled and made available so that tomato breeders throughout the country may select the plant materials that have particular promise in their work. The amount of research time saved in such a cooperative effort is enormous as compared with what would be needed to achieve the same result through the uncoordinated efforts of individual workers.

During the past year, a cooperative regional study on oak wilt was initiated by nine of the North Central States with the ultimate purpose of preventing the spread of oak wilt and of finding better control measures. Since oak wilt has also been found in Pennsylvania and West Virginia, these States have conducted research on this disease for several years, and they have also joined the North Central group in this study.

Oak wilt fungus spread by insects

Studies on oak wilt, caused by the fungus *Endoconidiophora fagacearum*, were continued by several stations during the past year. Excellent progress was made toward a better understanding of the life cycle and nature of the fungus, how it spreads, and its effect on wood. The Ohio station found that trees killed by oak wilt are just as good for lumber as those freshly cut. They must be harvested promptly after the disease completes its work, before the wood decaying fungi have time to destroy the lumber.

It has been known since 1950 that oak wilt could spread from an infected tree to a healthy one by root grafts, which could explain the spread of the disease in a small local area. This, however, did not offer a logical explanation for the overland spread of oak wilt to distances of a mile or more. Workers at several stations had observed that the oak wilt fungus produced cushions or mats beneath the bark causing it to crack and expose the spores. It had also been observed that insects were often attracted to the fungus by its characteristic odor, and in feeding, became contaminated with the spores. Since these insects were often found in fresh wounds on healthy trees, they were suspected of playing an important part in the overland spread of the oak wilt fungus.

Research conducted during 1953 by the Iowa and West Virginia stations has produced positive proof that a group of insects known as nitidulids, or sap-feeding beetles, can transmit the oak wilt fungus to fresh tree wounds, and hence, are important agents in the overland spread of the disease.

It has also been shown that these insects play another important role in the development of the disease, comparable to that of the bee in pollinating the flowers of orchard fruit trees. The fungus, like the orchard fruits, is self-sterile and must be "pollinated" or spermatized with spores of the opposite sex before completing its life cycle. These nitidulids, therefore, not only spread the oak wilt organism from tree to tree, but also spermatize the fungus, causing it to produce the ascospores which are highly resistant to adverse conditions, and probably play an important part in long-distance spread of the disease.

PROTECTION AGAINST INSECT DAMAGE

Entomological research at the State experiment stations is aimed at finding ways to cut down insect damage of both the obvious and obscure types. The more common kinds of insect damage are readily seen, such as wormholes in apples or potatoes, holes eaten in leaves or plants completely defoliated by caterpillars, or young plants chewed off just above the ground by cutworms. But there are other types of damage that often go unnoticed, such as the inability of alfalfa and other plants to set a full crop of seed because sucking insects have prevented them from doing so, the slowing of plant growth by root-feeding pests, the dying or defoliation of trees as a result of insects and mites that take sap from leaves and stems, and the development of diseases in plants and animals as the result of unseen or inconspicuous bites of insects, ticks, or mites. Both obvious and obscure types of insect damage often require extensive basic research and carefully controlled experiments before practical control measures can be recommended. The following summaries indicate that real progress is being made by the State stations in developing protection against insect damage.

Mite Damage to Apple Trees

Tiny European red mites that infest apple trees can reduce yields for two seasons if left alone to feed on the fruit buds, the New York State station reports. In commercial orchards, mite-controlled Cortland trees yielded 28 percent more apples per tree and showed 10 percent more growth than the mite-infested trees during the first year. In the second year, mite-controlled trees had four times as much bloom and produced 65 percent more apples per tree than the mite-injured trees. However, contrary to reports made previously, by other scientists, better color occurred on fruit from mite-injured trees, at least in the variety Cortland. Leaf growth was not as dense in the mite-injured trees which permitted better sunlight penetration to the fruit. Therefore, fruit from the infested trees had better color than fruit from mite-controlled trees. Mite feeding reduced the leaves' chlorophyll content as much as 15 to 35 percent, depending on the variety of tree and the intensity of infestation. Mites did not affect fruit firmness, even after several months' storage, nor did they affect the fruit's total soluble solids.

Corn Borer and Earworm Control

The European corn borer and the corn earworm cause severe damage to sweet corn as well as field corn. Proper timing of insecticide applications is very important in controlling both pests. The Massachusetts station showed that, in order to be effective, sprays and dusts must reach the young corn borer caterpillars in the early stages of development. Regardless of the growth stage of the corn, the most accurate measure for timing insecticidal treatment was based on the first hatching of the egg masses in the field. When treatment was delayed until the larvae were one-third to one-half grown, they burrowed deeper into the plant and became true "borers." These pests, which cannot be reached by insecticides applied to the surface of the plant, lower the vitality of the plant and reduce the size and quality

of its ears. DDT and newer insecticides protected the corn for about a week. Three applications at 7-day intervals adequately controlled the borers.

The Alabama station found proper timing very important in controlling the corn earworm in sweet corn with DDT sprays. The best time for the first spray was found to be when 10 percent or less of the stalks were in silk, about 1 or 2 days after the first silks appeared in the field. However, if the infestation was heavy and eggs were being deposited freely on the leaves and shoots before the silks appeared, earlier applications were made. Sprays were applied at 3-day intervals until the silks were brown, which was usually 1 to 2 weeks before harvest. Four sprayings were normally sufficient. The station obtained 94.5 percent worm-free ears from the sprayed plots as compared with 19 percent worm-free ears from the untreated plots.

In tests on the control of the corn earworm infesting commercial plantings of sweet corn the Kentucky station applied a spray of DDT and mineral oil dispersed in water, using a self-propelled high-clearance rig. When four spray applications were made 90 percent worm-free ears were obtained on the treated plots and 6 percent worm-free ears on the untreated plots. Where infestation was lighter (45 percent in the check plot), one application of DDT plus mineral oil applied at 90-percent silking produced 89 percent worm-free ears. A series of DDT emulsion sprays, without the mineral oil, proved inadequate, as did also the DDT dusts. Taste panel tests of the treated ears showed that none of the treatments produced off-flavor.

Insecticide for Sweetpotato Production

Research on the chemical control of insects by the experiment station at the University of Puerto Rico has made the commercial production of varieties of sweetpotato, such as the pink Mameya UPR No. 3, possible for the first time in Puerto Rico. A more desirable, new, and practical means of controlling the sweetpotato weevil by the use of aldrin has been developed. For effective control, three operations were found necessary: (1) The soil was sprayed with 2 pounds of aldrin per acre; (2) planting material (either vines or tubers) was dipped in aldrin; and (3) spraying was done at monthly intervals. Tubers 100-percent free of weevil were produced adjacent to check plots in which 60 percent tuber infestation was present. The flavor of the treated tubers was excellent.

Cost of Alfalfa Weevil Control Reduced

The Montana station reported last year that the period in the life cycle of the alfalfa weevil at which practical control could be obtained at reasonable cost is at the time the adult weevils came out of hibernation and before they lay their eggs. Almost complete control was accomplished by one insecticide spray at that time. Although applications by airplane and ground sprayers were effective, it usually was necessary in connection with airplane applications to use more toxicant per acre in order to obtain comparable control.

Weevil control at this stage in the insect's life cycle has resulted in yield increases varying from 0.4 to 1.8 tons of hay per acre. Actual savings on treated areas are estimated at well over $1,000,000 in Mon-

tana alone. By continuing its research the Montana station has discovered that more than one insecticide is effective in weevil control and the cost of treatment has been reduced from $5.50 to $2 per acre. In the acreage treated in Montana, savings on cost of treatment approximated $250,000 in 1 year.

Control of Meadow Spittlebug on Legumes

The Indiana station has shown that alfalfa may be selected for degrees of resistance or attractiveness to the meadow spittlebug. Alfalfa selection C40 had a low population of nymphs (61 per square foot), whereas selections C42, A220, and A230 had very high populations (257, 205, and 222 nymphs per square foot). Alfalfa, although attractive to large spittlebug populations, may be selected for tolerance. Two selections had infestations of 124 and 158 nymphs per square foot and still produced 1.36 and 1.41 tons of hay per acre. Alfalfa selections may also be relatively intolerant to low spittlebug populations. For example, the varieties Atlantic and Washington, had infestations of 128 and 103 nymphs per square foot and produced 0.94 and 1.01 tons per acre, respectively. Although these yields are relatively low, they indicate the possibility of selecting varieties of alfalfa that are resistant or tolerant to meadow spittlebugs. This is good news, as experimental results have shown reductions in forage yields ranging from 20 to 50 percent when infestations were heavy.

In research on chemical control of meadow spittlebug, the Ohio station, as previously reported, has found that increases in hay yields of 25 to 30 percent were obtained after spraying to control this pest on legumes. The continued research on the control of spittlebugs has shown that fall applications of DDT, made early in September, reduced adult spittlebug populations an average of 83.7 percent and resulted in an average reduction of 94.8 percent in the number of nymphs the following year. Methoxychlor also gave promise of good results especially if treated forage is to be fall pastured. Fall applications of DDT or methoxychlor were inferior to springtime treatments of BHC or toxaphene but were satisfactory in reducing nymph populations to noneconomic levels. Fall applications had the advantages that the fields were then in better condition, the farmer's work load was less, no insecticide such as BHC that might contaminate succeeding root crops was used, and the possibility of an insecticidal residue on the finished hay was avoided.

Aphid Control Increased Alfalfa Yield

The Kansas station in research to protect alfalfa from insect pests found that pea aphid control increased the yield of hay from 2 to 2.5 times over check plots where aphids were not controlled. In the experimental field of Buffalo alfalfa on the day before the insecticides were applied, 5 sweeps with a collecting net captured from 2,554 to 3,566 aphids per plot. The check plots averaged 2,824 aphids per plot. Twelve insecticides were tested and 5, including DDT, gave good control. Infestation dropped on the untreated check plots to 2,074 aphids on the fourth day following treatment and the number of aphids on the DDT-treated plot was 68, which was 97 percent control.

The increase in yield of alfalfa in the plots treated with the 5 best insecticides was from 2 to 2.5 times that of the check plot. With costs for insecticide application at $2.50 per acre and with hay in normal years selling at $25 a ton, the farmer would have received a net return of $18.75 per acre for controlling the pea aphid. The hot, dry weather prevalent over most of Kansas after the alfalfa plots were harvested brought about extreme drought conditions that caused crop failures on the second and third cuttings. As a result, alfalfa hay sold for $50 a ton which represents at least twice the profit from pea aphid control on the first cutting.

How Insecticides Act

The development of resistance to DDT and other insecticides by houseflies and other insects has caused serious losses and forced changes in control measures that have often increased the cost of production. This induced change in insect resistance has stimulated interest in the physiological action of insecticides.

The California station is engaged in research to determine how insecticides act within the insect to produce their lethal effect. In this research, the station has shown that prostigmine is a highly effective inhibitor of fly brain cholinesterase, but that it cannot be used as a contact insecticide because its quaternary ammonium structure prevents the compound from penetrating the insect cuticle and lipoid nerve sheaths. Similar enzyme inhibitors have been synthesized and tested and one, a lipoid-soluble isostere of prostigmine, was found to be highly toxic to flies. The station has also shown by chromatographic methods that there is an enzyme in the gut of the cockroach that can convert parathion to its oxygen analog, and that this enzymatic conversion is apparently responsible for the toxicity of parathion. Parathion is an exceedingly potent insecticide that inhibits the action of the enzyme, cholinesterase. With further knowledge about the physiological reaction of insects to the different chemicals in insecticides, it may become possible to avoid or counteract the development of resistance in insects and to bring about more effective control.

Grain Kernels Internally Infested With Insects

One type of insect activity that can readily proceed without detection and does enormous damage throughout the world is the development of insects inside the kernels of stored grain. Studying this problem, the Kansas station developed a sound-amplifying system that will record the sounds made by insects within the grains. Best results with this device were obtained with a concrete box having walls and a removable cover 2½ inches thick, within which boxes of copper and Celotex surrounded the infested grain lying on the microphone. Insects in the larval, pupal, and adult stages can be detected within the infested kernels, although the egg and extremely early stages of larval growth cannot. The larva must be nearly a week old before sufficient noise is produced for detection. Low-frequency sounds are made by the movement of larva and pupa within the kernels, and high-frequency sounds by the chewing of the endosperm of the grain

by the larva. The grain kernels with hidden infestations used in this study were selected by means of X-ray techniques previously developed at the station.

This research has made possible the rapid evaluation of the effectiveness of fumigants. Thus the normal delay of several weeks previously required to observe emergence of surviving insects and the ineffectiveness of the fumigant can now be eliminated. This principle could be applied in another form by devising a method whereby grain could be monitored within storage bins, for infestation, without sampling or removing the grain from the bins, in much the same manner as permanent thermocouple systems are now used for checking the heating of grain in storage.

Combination Insecticide-Fungicide Seed Treatments

The value of fungicide treatments for seed before planting has long been recognized. Experiments at the California station since 1946, and several years of commercial usage of this method on many thousands of pounds of seeds, have demonstrated the value of adding an insecticide to a fungicide when treating many kinds of seeds. In its research on treating seed with insecticides, however, the California station found that insecticides cause a "predisposing" of the seeds to decay by low temperature *Pythium* spp., when the insecticides were used alone on seeds and under conditions that favor the growth of the fungus. This effect may be due to an upsetting of antibiotic balances in the soil brought about by the use of the insecticide. The station was able to obtain this effect in the laboratory and demonstrated that the use of an adequate fungicide usually checks the development of the fungus. The California station has experimented with many kinds of insecticides and has found that dieldrin at the rate of 1 ounce of 50-percent material per 100 pounds of large lima bean seed gives almost complete protection from the seed-corn maggot and can be used where wireworms are not a problem.

The California station has also shown that from ⅓ to 5⅓ ounces of 75-percent lindane per 100 pounds of seed, the rate depending upon the seed type, was the best all-round insecticide for the control of wireworms and the seed-corn maggot. Under most conditions, one treatment controls from 75 to 95 percent of the wireworms in the seed zone, and 95 percent of the seed-corn maggots attacking the seeds. The cost varies with the crop, but on sugar beets it is 7 cents a pound for the combination treatment, or, if the grower plants 5 pounds of seed, it costs 35 cents an acre. Control of wireworms by other methods may cost from $7 to $35 an acre, and no effective control of the seed-corn maggot except by cultural practices was previously known for certain kinds of crops. One sugar beet company in California, using a new type of continuous-flow spray treater developed by the State experiment station, has treated over 1 million pounds of sugar beet seed with a lindane-fungicide combination. Over 30 different types of seeds including sorghum, corn, barley, wheat, bean, melon, sunflower, onion, cotton, pepper, and tomato, have been treated with lindane in California.

FOODS

Food Processing, Storage, and Quality

Food processing, in the home or in the commercial plant, is an important step in making full use of food produced by the agricultural industry. Researches, such as those noted in the following paragraphs, have been concerned with improving the quality of processed foods, understanding the factors involved in quality production, and utilizing cull or surplus crops.

Controlled aging of country-styled hams

A rapid method of curing and aging country-style hams has been developed at the Georgia station which will result in decreased losses of home-cured pork from spoilage. Application of this method will reduce the time for aging and curing from the 9 to 12 months generally practiced to approximately 8 weeks, for the million country-style hams cured in Georgia annually.

The typical country-cured flavor develops with age. Any desired degree of aged flavor can be obtained by varying storage periods and by controlling storage temperature and humidity. Successful results were obtained in a study using 72 hams carefully selected from 550 grain-fed hogs and cured with a dry mix of 8 pounds of salt, 2 pounds sugar, and 2 ounces sodium nitrite per 100 pounds of meat. After a medium hickory smoke, the hams were stored at several different temperatures, the relative humidity being held constant at 65 percent. When stored at 100° F., country-cured flavor and color developed in 4 weeks; more slowly at 85° in 3 months; or gradually at 65° in 6 months. At 50°, 9 to 12 months were required.

Controlled aging eliminates weather hazards, insect damage, and loss of hams by mold and slime. Optimum quality hams may be available at any time of the year if cured and aged by this quick method.

Quality cranberry sauce

The gel strength of cranberry sauces varies with the pectin content of the fruit from which they are made. Research at the Massachusetts station indicates that the variations in pectin are due to cranberry bog location, variety, and temperature of storage. The benzoic acid content of the berries, believed to relate to their keeping qualities, is also influenced by the above factors, and decreases as the fruit ripens on the vines. On the other hand, the pectin content increases as the fruit turns from green to red, and then tends to decrease during storage of the ripe fruit. The effect of these chemical changes on cranberry quality has significance in the handling and selection of the fruit prior to marketing. The yield of cranberry sauce may be increased by as much as 10 percent per given weight of fruit if berries of high pectin content are used.

Home processing of juices

One advantage of processing fruit and vegetable juices at home is that they can be tailor-made to suit the individual family's taste. Research at the Oregon station on the preparation and blending of juices shows that there are many other advantages. Juices can be prepared

from fruits and vegetables which are not suitable for canning or freezing because of defective appearance, and which are frequently obtainable at low cost. Selection of raw products, however, is the primary controlling factor in making quality juice. Products which are defective as a result of injury by insects, molds, or decay should be discarded, for a few bad fruits or vegetables can impart an undesirable flavor and ruin an entire batch. Quick handling of crushed or ground material is essential for satisfactory home-processed fruit juices. After fruit is crushed with either food grinders, choppers, or extractors, the ground material will oxidize easily, and changes of flavor and color and vitamin losses will occur. Further delay in pressing juice from the crushed fruit, by either hot or cold methods, also causes losses in quality. Added sugar and ascorbic acid help to preserve flavor, color, and the general quality of the juice. Pasteurization and sterilization are the two heat methods recommended for preserving the juices. Freezing is a simpler method of preservation, although in juices extracted by the cold method, heating and cooling prior to freezing is important.

Aside from dehydrated foods, fruit and vegetable juices occupy the least storage space compared with that required for products processed in other ways from the same amount of raw materials. The juices can be used in many ways and may be consumed more readily, particularly by children, than other forms of food.

Food Preparation and Utilization

The acceptability of foods served in the home or institution depends not only on individual tastes and food habits, but also on proper food preparation practices. Recipes and formulas, and ways of using foods and food products, are best developed in the laboratory by research workers who understand the special functions and behavior of the basic ingredients. Investigations such as those noted below contribute to more varied and extensive use of the food supply.

Behavior of fats and oils in food products

Investigation of the specific uses of fats and oils in food preparation at the Oregon station has yielded information which may serve as a guide in their production and utilization.

The chemical and physical properties of vegetable shortenings, butter, oleomargarine, and seven lards from hogs raised on different feeds were found to correlate with their behavior in food products. Evidence has been secured that some fats have superior shortening value and that some are suited to long storage when incorporated in foods. Plastic fats of certain types are unique in their effect on texture of cakes, because of their ability to entrap air in tiny bubbles and to disperse readily throughout a batter.

Each fat performed in a different way, but the tests showed that soft, oily lards are preferable to other types of fat in pastry making. The ration of the hog did not affect the flavor of the lard. Some lards kept very well, but in general, vegetable shortenings had better keeping qualities. Flavor, texture, and keeping quality of frozen cakes were greatly influenced by the kind of fat used. Frozen cakes

made with butter kept best. White cakes baked from frozen batters were best if made with butter plus emulsifier.

Fats and oils have special functions in food preparation—they carry flavor, contribute to softness, tenderness, and delicacy of baked products, and produce characteristic flavor and texture when used for producing emulsions.

Guide for using nonfat dry milk solids

A large percentage of nonfat dry milk solids prepared for human consumption is used by commercial firms in the production of various food products. The homemaker buys these foods on the retail market and yet has not used dry milk solids extensively in products she prepares at home. Several stations have provided information which will serve to increase the use of these milk solids as a staple product.

Nonfat milk solids may be added to many recipes or may be substituted for fluid skim milk without changing the characteristics of the resulting product. Research at the New Mexico station showed that tortillas of excellent flavor and texture were obtained by the addition of 1½ to 2 tablespoons of nonfat dry milk solids to each cup of flour or harinilla used in standard tortilla recipes. Sieved pinto beans, in New Mexico diets recommended for infants and young children, were found acceptable when fortified with dried milk. Milk solids offer an economical means of adding much of the food value of fresh milk to the diet and supplement the incomplete protein of the wheat and beans which are an important part of the Spanish-American diet in New Mexico.

A study at the Missouri station on the properties and uses of nonfat dry milk solids shows that most baked products are improved by altering one or more ingredients in recipes containing large amounts of the solids. For example, an increased amount of fat improves the tenderness of most baked products; and inferior product may result unless flour is decreased or liquid is increased to compensate for dryness in a batter or dough. Nonfat dry skim milk is high in milk sugar, and its addition to a recipe already containing considerable sweetening may make the product too sweet, thereby changing the texture and causing it to brown too quickly. The Missouri station recommends a reduction of sugar and a lowered baking temperature to overcome these difficulties.

The use of this form of milk solids in quantity food preparation has been investigated in research at the Wisconsin station. A taste panel determined the acceptance of products prepared with milk solids and found that preference was not significantly decreased by increasing, within limit, the milk solids content of dishes typical of those appearing on quantity food service menus. Although preference for these products was not increased by increasing the milk solids content, the findings of the study have significance for dietitians who plan meals for persons who benefit from liberal quantities of milk in the diet.

The Michigan station has reported comparative cost figures for using nonfat milk solids instead of fluid whole milk, which show that a saving of $16,000 yearly could be effected by the use of the nonfat milk solids in all institutional food preparation at Michigan State College.

HUMAN NUTRITION

Research furnishes the facts that are basic to an understanding of the nutritional requirements of the body and the effects of good or poor diets on body functions and development. Many of these facts are obtained by investigations with experimental animals. Others may best be obtained by observing population groups on their self-selected diets, and by studies of the effects of dietary inadequacies or of planned diet improvements. Following are examples of such investigations.

Milk, a good food in the last third of life

Studies with experimental animals, carried through their entire life span, are giving investigators at the New York (Cornell) station basic information that has possible significance for prolonging productive human life. These studies show, in part, that as age progresses the assimilation of calcium becomes more difficult. Milk, however, was found to provide a readily assimilable source of calcium for the older animal. This was reflected in the fact that animals on a milk diet had strong bones and sound teeth even in old age. The implications of these findings for the well-being of our older people has spurred the Cornell investigators to develop formulas for the use of more milk in baked products. During the past year the use of "Cornell Formula Bread," with its level of 8-percent dry milk solids, has increased, and the first open-formula mix for making bread and other baked goods has gone on sale throughout New York State.

Dietary deficiencies in early life

The effects of dietary deficiencies in the young animal may not be entirely corrected by subsequent improvement in the diet. This is the observation of research workers at the Florida station who are using white rats in a study of the effect of early dietary deficiencies on the subsequent life pattern. In this investigation, it was found that weanling rats, first fed diets low in calcium and phosphorus to the point where they showed deficiency symptoms, and then realimented on a good diet, took a long time to catch up in weight with the controls that were fed from weaning on the good diet. Even then, the calcium-deficient animals failed to maintain growth along with the controls. Bone fragility, as revealed by X-rays, joint deformities, and other bone abnormalities persisted in the deficient group into adult life. Other animals, depleted in vitamin A when young and then realimented on diets containing the vitamin, showed the aftereffects of the deficiency in their increased susceptibility to lung infection and in degenerative decalcification of the bones.

The significance of these findings to human nutrition was emphasized by other research at the Florida station concerned with development of the wrist bones in children 6 to 8 years of age. Among the 500 children X-rayed a considerable proportion showed delay in development, and light mineralization of the wrist bones. Dietary histories of these children from infancy suggested that the primary reason for the retarded bone development was the low consumption of foods rich in calcium and phosphorus, notably milk.

FAMILY AND FOOD ECONOMICS

The rural family profits from an analysis of its own income, spending, saving, and management pattern in comparison with the patterns of similar families in the region. Studies such as those here cited help the rural family in making plans for future spending and saving in relation to income, and for purchasing goods and services to meet home and family needs.

Incomes of families in industrialized rural areas

Industrialization of rural areas provides families residing in these areas with opportunities for off-farm work. South Carolina station research workers, in a study of levels of living in an area of increasing industrialization in the State, found that such employment provided nonfarm rural families with greater cash income than that of the farm families, but did not necessarily increase total income. Preliminary analysis of the data obtained by interviews with the families in the area indicated, for example, that in the medium income group the average cash income of the nonfarm families was about $700 a year more than that of the farm families. When the average nonmoney income—consisting of the value of home-produced food at farm prices, home-produced wood, and housing—was added to the cash income, the nonfarm average was only about $200 more. Valuing home-produced food at retail prices made the average total income for the two groups about equal. Nonfarm families tended to buy more on the installment plan than did the farm families, but the amount invested in such purchases was about the same.

Income and living costs of Kansas farm families

Kansas Farm and Home Management Association families have long cooperated in a study at the Kansas station of farm family income and living costs. Analysis of the accounts for 1951 submitted by 320 families gave the following basic information, useful for future planning.

These families averaged 3.98 members each. They operated farms averaging 800 acres; 37 percent of the farms contained between 200 and 500 acres; 14 percent contained between 1,000 and 2,000 acres; and 8 percent contained more than 2,000 acres. A part or all of the land was owned by 77 percent of the operators.

Net farm income averaged $5,648, an increase of $1,566 over the average for a similar group of families in 1950. The total value of all items purchased and those produced on the farm for home use was $3,272, of which $501 was the value of the home-produced items. In addition, these families reported gifts and contributions amounting to $255. Their savings and life insurance averaged $329, personal and income taxes averaged $299.

The largest item of expense for family living was that for food, which averaged $1,203. Clothing expenses, amounting to $343, was the next largest item, followed by furniture and equipment $334; health $236; household operation $241; education, recreation, and money allowance $211; contributions $163; automobile $115; personal gifts $92; and personal care $91.

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Saving and spending patterns in Illinois farm families

Farm family consumption patterns have been studied by Illinois station investigators who for 20 years have had the cooperation of a homogenous sample of farm families in keeping their expense accounts. Analysis of the records of 131 families reporting in both 1951 and 1952, showed a 3-percent increase in the average money available for family expenditures, savings, and income tax payments in 1952 over 1951. The greatest increases occurred in families established for 15 to 24 years, but even in these families, nearing the peak load of the marriage cycle, nearly all of the increased money available went into investments. The pattern of spending varied little for the two years except for a slight increase for medical care and recreation in 1952 and a decline in clothing expenses. Television sets, contributing to recreation in the home, were owned by 18 percent of these families by the end of 1952. The other expensive item of equipment most frequently purchased among the 131 farm families was the freezer locker, which was in 55 percent of these farm homes by the end of 1952.

Cost of home freezer operation

The increased use of home freezers has raised many questions in regard to their economy as a means of preserving foods. Indiana station investigators have obtained information on the operating costs of freezers in actual home use to determine the effect of freezer size and location on the amount of electricity used. Their study has shown that the average kilowatt-hour consumption per cubic foot of storage capacity was greater for smaller freezers than for larger sizes. Freezers located in heated rooms of the house used more electricity than those located in unheated basements, garages, or porches. Home freezers have been in service less than 10 years in Indiana and very few, if any, have been worn out and replaced. No information was available, therefore, on the total years of service that could be expected before replacement, but kilowatt-hour consumption did not seem to be affected by the age of the freezers used in the study. This indicates that present types of home freezers retain their efficiency and can be expected to give reliable service with only periodic inspections by qualified service men.

Studies at the Arkansas station on the kilowatt-hour requirements of household and farm electrical equipment, including home freezers, showed that average electrical consumption of freezers in farm homes varies from a low of 51 kw.-hr. for the month of December to a high of 99 kw.-hr. for the month of July. This was attributed to the higher outside temperature and to the increased volume of farm produce frozen and stored in the freezer during this summer month and, perhaps, to the more frequent opening of the freezer door.

TEXTILES AND CLOTHING

A considerable and recurring item in the family expense account is that for clothing and household textiles. Researches that point the way to increased satisfaction with, and extended life of, these textile commodities are of particular interest. The following studies illustrate this type of research.

Effect of laundering on men's shirts

Experimental facts obtained at the Texas station help to answer the frequently asked question "does commercial laundering wear out shirts faster than home laundering?"

Men's white broadcloth shirts with fused collars were used in the laundry study which was designed to subject some of the shirts to regular commercial laundering and others to laundering in the laboratory with modern home laundering equipment.

Examination of the shirts after each laundering detected faint signs of wear after 15 commercial launderings, but not until after 22 to 25 launderings by home methods. After 68 launderings, shirts handled by home methods and ironed with a hand iron showed no signs of wear other than a slight fuzziness of the collar edge; those ironed with a home ironer showed a few more signs of slight wear, especially at the buttonholes and around the collar edges and the collar band. The commercially laundered shirts, however, showed many signs of wear, including torn buttonholes, frayed collar edges, and broken yarns where the collar was bent and where it was attached to the band. The commercially laundered shirts not only showed more wear, but also were more yellow than those laundered by home methods.

Physical tests showed, further, that the commercially laundered shirts shrank sooner and slightly more than those laundered by home methods; after 68 launderings the commercially laundered shirts were only two-thirds as strong as home laundered and, chemically, the degradation of the cellulose of the cotton fiber was three times as great.

The hard wear accorded the commercially laundered shirts is attributed by the Texas investigators to the rather severe washing and bleaching treatment, the starching of the shirts, and the practice of buttoning and folding them, and creasing the fold in the collar with an iron.

By contrast, home laundering procedures used in the laboratory were not severe. They serve as the basis for the following recommendations to homemakers for obtaining maximum wear from shirts: The collar of the soiled shirt should be turned up before laundering and left up until the tie is in place. If starching is necessary, the amount of starch should be kept to the minimum. The shirt should be left unbuttoned until put on, and should be placed on a hanger rather than folded for storage.

Serviceability and care of marquisette curtains

Marquisettes are among the most popular materials for glass curtains, an item of considerable expense in the home. In-service studies of marquisette curtains made of various fibers have been conducted at the Oklahoma and Missouri stations in an effort to help the homemaker get the maximum serviceability for the money she spends for curtains and for the time and work involved in their care.

The findings of the Oklahoma investigators indicate that dry cleaning of rayon and cotton marquisete curtains leaves them with fewer breaks and holes, but with more stains, discoloration, and limpness than does laundering. In dry cleaning, rayon curtains yellow less and retain their crispness better than those of cotton, but in laundering

they suffer much more damage than the cotton ones. Starching of cotton curtains to improve their crispness has the disadvantage of increasing the attractiveness of the fabric to silverfish.

The study at the Missouri station shows that nylon, cotton, and rayon marquisette curtains decrease slightly in strength in a series of launderings. The fragility of the rayon when wet is particularly troublesome. Extreme care therefore, must be exercised in handling rayon curtains during launderings and in putting them on stretchers to dry. Shrinkage is sufficient, except possibly with nylon curtains, to necessitate lengthening of the curtains after washing. This is particularly true with the rayon marquisette.

DAIRY PRODUCTS

In contrast to the research in dairy production in which the major emphasis is on immediate economic value, dairy technology research deals mainly with fundamental problems or with highly technical phases of dairy chemistry, dairy microbiology, and the like. Many of these studies were begun in an effort to solve practical problems, such as why some batches of milk develop an oxidized flavor and other batches do not; why loaf volume sometimes shrinks when dry milk solids are added to the mix; how milk can be made sterile without changing its physical properties or losing its fresh flavor; and what happens to cheese during the curing process to give it a characteristic flavor. A few examples of the results of such research are summarized.

Flavor Is Important

Oxidized flavor is the most serious flavor defect of unhomogenized milk. Studies at the North Carolina station showed that peroxidase, xanthine oxidase, and ascorbic acid may cause the development of spontaneous oxidized flavor, whereas catalase, pH, Eh, fat, and the amount of milk a cow gives had almost no effect. Florida has been studying the effects of the following chelating compounds on oxidized flavor: (1) The disodium salt, (2) the tetrasodium salt, (3) the disodium calcium salt of ethylenediaminetetraacetic acid (EDTA), and (4) sodium diethyldithiocarbamate. At levels found to be adequate for protecting milk against the oxidized flavor caused by the addition of copper up to 5 p. p. m. no flavor defect was detected which could be attributed to the four compounds listed. Limited observations also indicated that at these levels milk was protected against flavor caused by sunlight. Contrary to findings elsewhere, the California station reports that copper contamination in market milk was not an important cause of the oxidized flavor in most of the defective samples studied. The California station did note, however, that washing and sanitizing treatments markedly increased the availability of copper from equipment with the result that contamination is highest in the first milk processed after the equipment has been cleaned.

Scientists at the Pennsylvania station report that methionine appears to be the substrate in which sunlight flavor develops in skim milk. Riboflavin, acting as a catalyst, is involved in the chemical reaction. The Illinois station found that preheating milk to 120° F. or heating it at 200°, 250°, or 300° for 2.1 seconds did not reduce its ascorbic acid content. This milk retained from 70 to 80 percent of its

ascorbic acid after 4 days at 40° to 45°. The ascorbic acid content of the unheated milk decreased from 18 milligrams per liter to about 2 milligrams per liter after 4 days' storage at 40° to 45°. Results of Vermont station experiments indicate that certain rancid tastes in milk may be due to feeding silage with a high butyric acid content, and that the disagreeable flavor noted is caused by feeding poor quality silage. To test this theory, the cows were fed high quality silage only 30 minutes before milking. Where no strong silage smell was allowed in the barn and other similar factors were controlled, no undesirable silage flavor appeared in the milk.

Some Effects of Heat on Milk

Of 66 psychrophilic organisms isolated from milk and water supplies by the Illinois station, none survived heating at 143° F. for 25 minutes. Their presence in pasteurized bottled milk appeared to be caused by postpasteurization contamination. The Michigan station has carried on experiments which indicate that the psychrophilic organisms causing spoilage of pasteurized milk are present in such small numbers immediately after pasteurization that they are not detected through standard counting methods.

Conventional short-time high-temperature pasteurization (161° F. for 15 seconds) has many advantages over the holder system (143° for 30 minutes), particularly for larger milk plants. The Massachusetts station has been experimenting with equipment that could be used to pasteurize milk while in continuous flow. Preliminary observations on flavor, phosphatase destruction, and *Escherichia coli* destruction with electrical resistance heating at 180° in 0.065-inch inside-diameter stainless steel tubing, gave satisfactory results when milk was heated as briefly as 0.1 second. Higher temperatures and longer holding time resulted in partial denaturation of the serum proteins. They found that 40 percent of the serum proteins are denatured in 1 second if the temperature reaches 290°. Denaturation is further accelerated, according to the Wisconsin station, if the pH of the serum proteins, beta-lactoglobulin in this instance, is between 6.7 and 7.77.

The precipitation of the heat-labile lactoglobulin fraction is desirable in the manufacture of nonfat dry milk solids used in the baking industry since it is this fraction which, when soluble, tends to cause reduction in loaf volume. The Minnesota station reports that amylase isolated from the lactoglobulin appears to be responsible for the reduction in loaf volume.

In the preparation of powdered whole milk for baking, the Washington station prefers to preheat the milk just enough to denature 75 percent of the whey proteins. This requires a temperature somewhere between 180° F. for 7 minutes or 170° for 30 minutes. Temperatures between 200° and 300° for the drying air in the machine had no apparent effect on the keeping quality of the powder. Condensing the milk at least 2 : 1 before spray drying appeared to improve quality.

The California station found that the heated flavor of evaporated milk can be minimized by sterilizing the milk at higher temperatures for shorter periods of time. However, when this process is used fat separation occurs when the milk is stored because the viscosity of the milk is not increased. To counteract the tendency of the fat to sepa-

rate out, the viscosity of the evaporated milk was increased by controlled enzymatic hydrolysis of the milk proteins. The amount of hydrolysis necessary to prevent fat separation was found to be so slight as to have no effect on the flavor. The Pennsylvania station showed that casein and lactose are the principal reactants in "browning" of heated milk and that this occurs at temperatures ranging from 100° to 120° C., depending on the time held. Milk which had been partly digested with trypsin also discolored less readily than undigested milk.

Preliminary trials with commercially processed concentrate at the Minnesota station showed that flavor remained satisfactory approximately one week longer when the milk was concentrated 4:1 rather than 3:1 and stored at 5° C.

The Indiana station, in a study made to answer the question, "How long can grade A raw milk be held at a low temperature before its quality is seriously impaired?" found that the numbers of bacteria increased significantly after 2 to 4 days even though the temperature was held at 40° F. The bacteria identified were largely of the psychrophilic type. At the Ohio station organisms ordinarily found only at high temperatures sometimes grew slowly at low temperatures.

Although the Food and Drug Administration, Department of Health, Education, and Welfare, has ruled against the use of chemicals or antibiotics for preserving milk, the behavior of these compounds is of considerable theoretical importance. Milk which has been preserved with hydrogen peroxide when fed to rats by dairy scientists at the Colorado station produced no harmful effects.

Quality of Cheese Continues To Improve

The Wisconsin station reports that Cheddar cheese made from pasteurized milk cures faster when the cheese is subjected to strong ultrasonic waves. The explanation given for this phenomenon is that the ultrasonic waves alter the milk components in such a way as to make them more readily available to the special types of bacteria which produce the desired flavor and texture of each kind of cheese.

Four different ripening treatments aimed at hastening flavor development in Cheddar cheese were studied by the Kentucky station. The most satisfactory method among the four was to hold the cheese at 60° F. for 4 weeks, then at 40° for an additional 8 weeks.

The Illinois station compared the intermediates in carbohydrate break-down during the curing process of acid, normal, and mild-flavored Cheddar cheese. The sharper-flavored cheese contained the greater amount of lactate compound. The lactate compounds reached a maximum approximately 90 days after curing was begun. The acetate compounds remained high in both the acid and mild cheese throughout the curing process.

Streptococcus lactis and *S. cremoris*, important organisms found in cheese starters, depend largely on peptone-peptide nitrogen and trichloracetic acid soluble nitrogen for early growth rather than on the native proteins of milk. The Oregon station found that reconstituted skim milk is improved as a starter medium by a short period of autoclaving (10 minutes at 148° C.) prior to inoculation. This brief period of heating apparently increases the amount of soluble nonprotein nitrogen on which the organisms feed. The research disclosed that

lactalbumin can also be utilized by the bacteria and that even casein is subject to hydrolysis by bacteria at its isoelectric point.

The Iowa station made a careful study of the enzymes secreted by *Streptococcus lactis*. *S. lactis* grown in milk at pH 6.0 to 7.5 produced considerably more soluble nitrogen and tyrosine and tryptophan than comparable samples held at pH values outside of this range. No proteolytic activity could be detected in the culture medium after the cells had been removed. Dairy bacteriologists sometimes refer to the advantages of starter cultures which become more or less immune to injury by bacteriophage. But the Iowa station warns that resistant strains generally grow and produce acid slowly. In one instance, mutation to bacteriophage resistance appeared to be accompanied by loss of the ability of the starter to ferment lactose.

Tennessee dairy scientists discovered that even though their Cheddar cheese starter cultures had been contaminated with *Leuconostoc citrovorum* they were able to overcome any tendency toward slit openness in the cured cheese by repeated transfer of the starter cultures at 32° C. prior to using. Apparently this treatment tended to destroy the gas-producing organisms that cause the defect.

The Ohio station (coop. USDA) found a close interrelationship between the free butyric acid and free glutamic acid content of Provolone cheese and flavor development. The best-flavored Provolone cheese contained 4.3 milligrams of butyric acid and 8.3 milligrams of free glutamic acid per gram of solids. The Indiana station continued its research with miniature Swiss-type cheese. By suitable packing methods, the station scientists have been able to materially reduce the amount of rind which must be discarded by the consumer.

The Utah station found that hydrogen peroxide in experimental cheese destroys bacteria in the raw milk without inactivating the enzymes. The Utah scientists point out that "the improvement of body texture, and eye formation which can be accomplished with the peroxide treatment is significant as a prospective contribution to the making of Swiss and other varieties of cheese."

A new cheese has recently been developed by the Wisconsin station. It is a natural cheese with creamy flavor and soft body characteristic of processed cheese. A cultured cream spread and salad dressing was perfected by the Missouri station. It was well received by large numbers of consumers at various economic levels, managers of milk and milk product plants, research groups, and supervisory personnel. Its flavor is described as rich, clean, pleasing, with a medium-sharp acid tang.

Tests for Nonmilk Fats

Considerable thought and study is being given to simple methods of identifying nonmilk fats when mixed with milk fat. The Maryland station has developed a presumptive crystallization test by which it is possible to detect as little as 5 percent of corn oil, peanut oil, cottonseed oil, coconut oil, partly refined coconut oil, beef fat, and three different brands of hydrogenated vegetable fat. Refined coconut oil was the most difficult foreign fat to detect when mixed with milk fat. Its identification by the Maryland method cannot be positive unless the mixture contains at least 10 percent coconut oil. The test is not read until about 1 hour after the sample has been pre-

pared and placed in a water bath so that the characteristic crystallization pattern will have had time to develop. The Iowa station attempted to identify fats foreign to milk by measuring the tocopherol values of the respective mixes. This test proved practical at the 10-percent level for most fats except coconut and soybean oil. Coconut oil could not be positively detected at any level and soybean oil could not be detected below the 20-percent level.

The Indiana station determined the effect of various dairy cattle feeds on the characteristics of the butterfat produced. The amount of oleic and linoleic glycerides present was much lower when corncobs were fed than when alfalfa was the principal roughage in the ration.

The Maine station has shown that tocopherol is the natural protective agent that prevents butterfat test loss in composite samples. This vitamin is not present in sufficient quantity in preserved roughages and ordinary grain mixtures fed to dairy cows to attain the tocopherol level necessary to prevent milk fat hydrolysis. However, it would not be as expensive as an additive to milk samples for testing and it would be as effective in preventing butterfat test loss as acetaphenone and butyrophenone.

Ice Cream Manufacturers Interested in Shorter Whipping Time

Ice cream tends to whip slowly when hard water has been used to reconstitute the dry milk solids in the mix. Whipping time was increased 20 percent, according to research at Florida, when plastic cream and hard water were used, unless an emulsifier was added. When the hard water was softened by means of a sodium ion-exchanger, the resulting mixes were equal in whipping quality to the control mixes.

A final report has been released by the Pennsylvania station on its research dealing with the causes of shrinkage in ice cream. This report contains dozens of suggestions on how to guard against shrinkage. With respect to the action of added caseinates, the report states: (1) In all cases the addition of sodium caseinate drastically reduced shrinkage; (2) superheated and powered sodium caseinate decreased shrinkage the most; (3) 15 percent of the serum solids content of the mix was the maximum amount which could be used without producing too much overrun; and (4) the caseinates imparted very fine body to the ice cream, ammonium giving the best results.

The Storrs station (Connecticut) suggests that lemon or chocolate flavor is a good substitute if a manufacturer desires something different from the usual rum-vanilla-flavor in eggnog.

Modern Sanitizing Compounds Require New Techniques

The experiment stations are continuing to develop better methods for keeping dairy equipment clean. Some of the experiments lead to unexpected results. For instance, the Wisconsin station found that alkaline can-washing compounds are more than 10 times more corrosive on tinned steel than on stainless steel. The chelating compound sodium tripolyphosphate was studied at the Oregon station. It increased the germicidal activity of two quaternary ammonium compounds by inactivating part of the salts in hard water. Labora-

tory tests also demonstrated that alkaline cleaners used for cleaning "in-place" pipelines in dairy plants could be markedly improved by the addition of sodium hypochlorite to the cleaning solution. Although hypochlorite is usually thought of as a germicidal agent, the Oregon experiments showed that it has a solubilizing effect on the protein of milk deposits in equipment. The Massachusetts station has discovered that a group of iodine-containing substances called iodophors may prove to be useful in sanitizing dairy equipment. Iodophors are not affected adversely by hard water. Compared to iodine, they have greater germicidal activity, less odorous properties, and less staining and irritating action.

The Illinois station confirmed findings elsewhere that cleaning the milking equipment without dismantling results in as low bacterial count as when the pipeline, milker pail, and teat cup assembly are dismantled for cleaning. However, the data revealed that the time required to prepare the cows for milking, to sanitize the units between cows, to apply milkers, and to machine strip was approximately the same whether a pipeline system was used or the conventional machine system. Pipelines excessively contaminated by application of improper sanitation methods can be readily restored to a hygienic condition by resuming correct rinsing, washing, and sanitizing operations.

The Storrs station (Connecticut) has developed a machine for grading milk microscopically. It indicates automatically the upper and lower limits (numbers of bacteria or clumps) above which all milk should be discarded and the lower limit necessary for its acceptance as Grade A milk. This machine is an outgrowth of the multiple-sampling sequential plan of grading milk (1952 Annual Report, p. 90).

Milking Machines

After 104 trials with new and used teat cup liners the Kansas station calculated that used liners were 19 times as susceptible to contamination as new liners. Under practical milking conditions, the differences were even greater. Used liners rapidly built up high counts during the first milking period after being sterilized. Preliminary trials indicate that although dry storage between milkings can be satisfactory for new rubber, it gives poorer results with used liners.

Oklahoma has found that bacterial counts, both the standard plate count and the coliform count, were much lower on the average in the milk that was handled by the bulk system than on milk handled by the can system.

BETTER MARKETING THROUGH RESEARCH

Research in agricultural marketing has been a part of the State experiment station program since the passage of the Purnell Act of 1925. Further emphasis on the need for research in this field was given under authorization in the 1946 amendment of the Bankhead-Jones Act of June 29, 1935, and under the Agricultural Marketing Act of 1946. Studies by the experiment stations are directed primarily at improved marketing and distribution methods dealing with commodities of economic importance within the respective States. Examples of results from such research follow.

Markets for Alaska's Agricultural Products

Although Alaska is large, it has few farms. Alaskan farms could, however, produce more food if farmers were sure of a market for their crops. A prejudice against local produce is being overcome slowly, although much producer and consumer education is still necessary. Milk production in the Matanuska Valley has jumped nearly 200 percent in the last 9 years to a record 5,200,000 pounds. Egg output has increased from 21,000 to 103,000 dozen and dressed poultry is up from 3,350 pounds to 21,000 pounds.

The Alaska station completed a consumer study which shows that most housewives prefer local rather than imported products, if price and quality are similar. Many women could not tell the difference in produce by appearance alone. The survey recorded the use of local products in Anchorage and Fairbanks. In both cities, about 38 percent of the milk used by families in the survey was fresh. All fresh milk consumed in Anchorage came from local farms, whereas 42 percent of fresh milk in Fairbanks was airborne. Over half of the milk consumed in both cities was concentrated. Consumers purchased all the local eggs they could get. In Anchorage, 27 percent of all fresh eggs were of domestic origin compared with only 2 percent in Fairbanks. Between 50 and 60 percent of the potatoes consumed were produced locally, and when Alaskan potatoes were in peak season, they comprised over 75 percent of the potatoes consumed.

Peanut Marketing

The Georgia station has conducted experiments to solve problems in peanut sampling, grading, and shelling, caused by the presence of foreign materials. Equipment designed to test the proposed methods had been installed in a pilot plant at Bainbridge.

The station developed a new process for cleaning peanuts which is now in commercial operation. A rotary-disk sizing machine was built, and one model is now being operated commercially. A sampling analysis showed that a larger sample (2 pounds) gave more accuracy in grading. Consequently, two semiautomatic shellers for sampling peanuts were built, and experimental models are now being tested. An automatic method for obtaining samples as the peanuts are unloaded has also been developed.

Improvements in Harvesting Potatoes

Further application was made in the past year of the rubber protection principle in potato harvesters reported last year by the Idaho station. The Alabama, Florida, North Carolina, and Virginia stations (coop. USDA) conducted marketing studies that showed that physical injury to potatoes could be lessened at an economic saving to farmers through improvement of harvesting equipment.

It was found that fewer potatoes were damaged when the speed of digging was reduced and when rubber-covered baskets were used as pickup containers. The potatoes were further protected from digger injuries by having a rubber tubing cover on every link of the digger chain, and by web belting along the sides of the digger frame. These modifications cost $1 per acre when the digger was used to harvest

40 acres annually, and materially decreased the number of potatoes thrown out or placed in a lower grade.

On-the-Farm Grain Storage

Grain storage facilities can be built on Montana farms at a cost of materials ranging from 20 to 60 cents per bushed capacity, depending on type and size of structure, according to a study made by the Montana station.

The benefits from farm storage facilities are: (1) It increases the possibility of gains from seasonal increases in the price of grain, (2) it provides an opportunity to take advantage of Commodity Credit Corporation loans, (3) it reduces the cash outlay at harvesttime, and (4) it insures savings on Federal net income tax. Thus a northeastern Montana spring wheat farmer, living on a 500-acre-crop unit 10 miles from town, could afford to construct storage space for two average years' crops, at 1951 price levels. Good farm storage facilities in Montana were available in 1951 for about 90 percent of a previous 10-year-average grain crop.

Packing Deciduous Fruits

In California, Washington, and Oregon, shipping costs for apples, pears, and table grapes total about 65 million dollars per year, almost as much as the farmers receive for their fruit.

Research done by the California station (coop. USDA) showed that costs of fruit shipping can be reduced by greater efficiency within the shipping plant. Shipping costs of fresh California pears indicated a range in labor and equipment expenses from 42 to 60 cents per standard box. Packing labor studies showed that 30,000 man-hours per year could be saved in packing pears and 16,000 man-hours per year in packing California apples. Costs of transporting fruit within the packing house ranged from $0.47 to $1.15 per 1,000 pounds. Similar variations in expense were found for other operations: Orchard-to-plant transportation, and dumping and sorting of incoming fruit. These expense variations indicate the possibilities for cost reduction. The station showed that some cost reduction is possible even in the most efficient plants.

Handling Tobacco on Warehouse Floors

Efficient organization and equipment saves labor in packing burley tobacco for sale, the Kentucky station reports. A study of work methods shows that more is accomplished when only two men work together as a packing team, when two workers of equal skill are teamed together, when stick racks are used, and when workers are taught efficient methods. When basket and stick rack are placed close to the tobacco, the stickmen can pick up and pass the tobacco without moving. The packer works best when he packs at least one-half stick of tobacco at a time, places it in the right spot with one decisive motion, and shifts his position only after each full stick is packed. Farmers can help improve efficiency by using straight smooth sticks for the tobacco, by sorting tobacco properly while stripping, and by pressing tobacco for ease in handling.

Nebraska Cream Collection

The Nebraska station has found that methods of cream collection, as practiced in a large portion of the State, lower the quality of the cream because of poor storage and transportation conditions. Most of the cream is collected through cream-buying stations and processed in "centralizer" plants. Long delays in getting the cream from farm to creamery allow boichemical changes in the cream structure to take place.

If quality cream is to be marketed in Nebraska, collection methods should be improved. Creamery truck routes and direct farmer deliveries to the creamery insure a higher quality of cream than collection methods generally followed in Nebraska. Buying stations must give way to more rapid collections, or cream storage methods must be improved.

Market Preference for Lean-Type Hogs

As reported in 1949, 10 State experiment stations (coop. USDA) have sought information whereby livestock marketing practices could be improved to satisfy consumer demand for certain types of meat and thus serve as an incentive to farmers to produce the type of animal for which there is premium demand.

The Minnesota station has obtained information on the standardization of hogs, adaptation of hog types to market preferences, and on sales based on hog quality and yield, as practiced in Denmark and other European nations. This information bears directly on changes in production, handling, grading, pricing, and marketing of hogs in Minnesota to fit consumer preference and requirements, and to improve returns to farmers. A weak market for lard and a demand for leaner meat indicate a need for leaner type hogs.

Consumer Preferences in Buying Potatoes

City consumers are willing to pay more for washed than for unwashed potatoes, according to a consumer acceptance study made by the Ohio station in four Columbus chain stores during two marketing seasons. Even with a 1-cent premium, washed potatoes outsold unwashed ones.

The type of container used had no appreciable effect on sales of unwashed potatoes. However, the 1951 study showed that the customers preferred paper mesh-window containers to solid paper bags for washed potatoes, although there was a 2-cent premium on the mesh-window bags. In 1952, washed potatoes in semitransparent polyethylene plastic containers outsold washed potatoes in the mesh-window bags at the same price. If the problem of filling, closing, stacking, and displaying polyethylene bags can be solved, these containers should make good potato bags because of their low cost and high consumer acceptance.

According to the Maine station, customers in the Bangor market preferred transparent plastic bags to types of containers that give shoppers only limited opportunity to inspect the quality of potatoes at the time of purchase. Through purchases, customers also expressed their desire to have potatoes washed prior to sale. Although shoppers demonstrated their willingness to pay the added costs for these services,

washing and packing in plastic bags are not substitutes for quality in developing consumer acceptance and satisfaction with potatoes. Consumers appear to evaluate potato quality as a combination of cleanness, appearance, and eating quality. Merchandising practices which disregard these concepts of quality have little chance for success.

Dairy Production and Consumption in West

Dairy production by the Pacific Slope States will be able to meet the demands of increased population in the area as it has done in the past, according to research at Washington and other Western stations (coop. USDA). Reports of the seven States in the Pacific Slope area showed that 12,602 million pounds of whole milk or milk equivalents were available in 1949; 90 percent was produced in the region and 10 percent was shipped in from the Rocky Mountain and Midwestern States as butter and cheese. About 7 percent of the total was shipped out of the region to offshore movements, and 93 percent was consumed within the area. Estimates show that annual milk production in the region should reach 12,500 to 16,500 million pounds by 1960. Consumption is estimated at from 14,100 to 18,100 million pounds. This would represent a balance between production and consumption levels of dairy products similar to that maintained in 1949.

Efficiency in Meat Merchandising

Efficiency in meat merchandising can be greatly increased in many Indiana retail stores, according to research conducted by the State experiment station. Improvements could be made in buying and pricing policies, accounting procedures, personnel training, and by reducing losses from dehydration, cutting, and spoilage.

Prices were established in several ways: 54 percent of the retailers reported using a percentage markup over cost to fix prices; 15 percent used a 1-cent-per-pound markup; 18 percent used a percentage of selling price (margin); and 13 percent based their prices solely on competition. Only 42 percent made cutting tests to check the profit made on the calculated price. Poor records kept by many retailers indicated that they did not actually know the profit or loss made in their meat departments.

Stores were purchasing meat from 1 to 11 suppliers. The average number of suppliers of all stores was 5, of which 4 were packers and 1 a wholesaler. Retailers could reduce their number of suppliers to save their own and the supplier's time.

Seed Cotton Storage

Studies at the Texas station have shown that cotton may be stored in the gin yard and in the field more profitably than in the seed cotton house. Two large gin seed-cotton houses in the Gulf Coast area were examined during 1947, 1948, and 1949. The size of the house and the rate of turnover determined the amount of seed cotton that could be stored. The turnover of cotton was low, even when there was a surplus of seed cotton in the gin yard. Ginning efficiency was not improved by storing cotton in the house. Results showed that cotton could be ginned off the yard at less expense.

The 1949, 1950, and 1951 crop studies in the High Plains area showed that mechanically stripped seed cotton can be stored in the field. In January 1952, field-stored seed cotton was exposed to 1 inch of moisture in less than a week. Seed cotton stored under similar condition at the Lubbock Substation and wet artificially with two more inches of moisture, in two applications, retained its same grade. Spinning and fabrication tests indicate that strong and durable fabrics can be made from field-stored seed cotton.

Market Prices for Broilers

Broiler prices are most affected by changes in meat prices and placements, according to research at the Pennsylvania station. Price and production changes in different broiler-producing areas occur simultaneously. No area maintains a price superiority or initiates price or production changes. Seasonal patterns of broiler production show low placements in late summer and high placements in early spring. Seasonal production swing is not great, however, and most seasonal variation has disappeared.

About 77 percent of the farm price variation for broilers in Delaware, Maryland, and Virginia was associated with: (1) Difference in chick placements in the previous 3 months; (2) the Bureau of Labor Statistics index of wholesale meat prices; (3) the quantity of farm chickens sold; and (4) the relation of time of marketing to supplies of other meats available.

Results showed that producers should watch meat price and placement data sent out from the USDA. When more meat is being placed in major areas and meat prices are decreasing, lower broiler prices may be expected, and vice versa.

ECONOMICS OTHER THAN MARKETING

Economic research is often closely related to research in the biological and physical sciences because technical knowledge will not be generally accepted until it is demonstrated that use of the new information or practice will be profitable. The farmer is also concerned with forces and conditions over which he has little direct control. Prices received and paid, taxes, insurance, and credit are also of the utmost concern and require study. The State experiment stations conduct a wide range of studies in farm management, prices, farm finance, tenure, and many other economic problems confronting farmers. A few examples of results from such research are here presented.

Factors Affecting Livestock Earnings

A study of the factors affecting the earnings on livestock, conducted by the Illinois station, indicates that health of animals is closely correlated with net income. Keeping hogs healthy so as to wean large litters, avoid death losses, and make rapid gains was shown to be of greatest importance in getting profits from hogs. Hog profits are also increased by providing more protein and mineral feeds and more pasture for the animals. Relatively heavy death losses frequently occurred when large numbers of feeder pigs were purchased. It was found that high earnings per $100 worth of feed supplied to beef cow herds, was more closely associated with low death losses in the herds

than any other factor studied. The feeding of relatively small amounts of concentrates per 100 pounds of beef produced was also positively correlated with high cattle returns. Low death losses in the dairy herd were also more closely related to high dairy cattle earnings than any other factor.

In a study of the returns from beef cattle the Mississippi station learned that farmers with good cows, low feed and pasture costs, and following good health practices netted $55 per head, whereas a loss of $25 per cow was incurred by farmers with poor cows, high feed and pasture costs, and not following good health practices. Findings were summarized as follows: Farmers with a good cow, low feed and pasture costs, and good health practices, realized a profit of $55; with good cow and low feed and pasture costs, a profit of $47; with good cow and low feed cost, a profit of $33; with poor cow and high feed cost, a loss of $3; with poor cow and high feed and pasture cost, a loss of $6; and with a poor cow, high feed and pasture costs, and poor health practices, a loss of $25.

Average returns per cow varied from a profit of $127 to a loss of $5, the Michigan station found in a study of beef cattle producers. The high-profit farmers got a higher percentage of the cows with calf, bred cows early so that calves were born in March and April, had good quality cows and bulls, provided an adequate supply of good quality pasture, and followed followed management practices that resulted in the calves being well developed and of good quality and uniform size by the sale date.

A study conducted by the South Carolina station (coop. USDA) indicated that a large part of the idle land in the State could be profitably used for grazing and that grazing systems could be established that would produce about 300 pounds of beef per acre at an annual cost of 10.5 cents per pound.

The Indiana station made an analysis of the factors involved in operating pig hatcheries profitably. The following factors were found to be necessary for profitable operation: (1) Top level know-how and management; (2) competent labor; (3) an investment of at least $135 per sow for buildings and breeding stock; (4) ability to withstand some seasonal slumps in prices; and (5) readiness to feed some of the pigs to market weights if necessary.

Feeder pigs, it was found, fit best on farms where: (1) Labor, know-how, and experience are short, yet feed is plentiful; (2) operators are willing to pay a little more to avoid the chores of castration, vaccination, and care of the breeding herd—and perhaps get a superior product; (3) a more uniform seasonal distribution of labor is desired; (4) hogs are a sideline enterprise or large numbers are fed on by-product feeds; (5) more control is desired with respect to the time at which finished hogs are to be marketed; (6) a farmer is a high-cost producer and capital is available; and (7) pigs can be given close attention when purchased. Hatchery pigs may be regarded as a "hot-house" product and seller's instructions on feeding and housing should be considered.

What Makes a Successful Dairy Farm Operation?

The Delaware station made a study to determine the factors that make some dairy farms more successful than others. Out of a total

of 77 farms studied, it was shown that those yielding above-average returns produced 19 percent more milk per cow, used 23 percent less labor, and sold 9 percent more milk during the October–March period than the average. These dairy farms produced milk for 67 cents less a hundredweight and sold it for 25 cents more than the average. They also received almost twice as much return per hour of labor and 67 percent greater labor return per cow.

The Mississippi station found that the investment in the dairy enterprise per cow varied from $460 for Grade A producers to $365 for Class C producers. Investment in buildings and equipment per cow and the amount of labor utilized per cow tended to decrease as the size of the herd increased. Results of the study indicate that dairying could be made more profitable by better management in several phases of the dairy enterprise, especially by having a better balance between concentrates and roughages and by a more efficient utilization of grazing lands. Most producers could reduce the per unit cost of feed and pastures by furnishing a larger proportion of hand-fed feeds in the form of good quality roughages; by producing a larger proportion of the feeds consumed by the dairy herd; and by increasing the carrying capacity of pastures in some cases and heavier stocking of understocked pasture in other cases. Production profits could also be increased by improving the quality of the herd and by having a larger proportion of the herd freshen during the late summer and early fall.

A great variation in production efficiency of dairy herds exists in the Detroit milkshed. In a study of this subject, the Michigan station (coop. USDA) learned that the average labor and management returns per cow in the upper fifth income group was $256, as compared to $67 in the lower fifth income group. The station recommended to dairymen desiring to increase profits that they: (1) Produce a large volume of milk, each man caring for a minimum of 20 cows that produce at least 10,000 pounds of milk; (2) feed a high quality of roughage and a grain ration based on the inherent capacity of the cow and the milk-feed price relationship; (3) increase labor efficiency by keeping the herd of efficient manageable size, have an efficient barn arrangement, make use of labor-saving equipment, and improve work methods; (4) have cows freshen in the fall; and (5) care for and manage the herd so as to lengthen the productive life of each cow and thus reduce replacement costs.

The Wyoming station in an analysis of cost account records kept by a group of dairymen over a period of 5 years, found that they had paid particular attention to the relative effects of alternative management practices such as crop rotations, scientific feeding, and other factors. By keeping records of their physical and financial operations they were able to find ways of increasing efficiency. Between 1948 and 1952, these dairy farms showed substantial increases in per acre yields of forage and grain crops and a larger production per cow. The Vermont station found that individual farm planning paid off in larger labor incomes. Farmers who had farm planning guidance increased their labor income from $1,552 to $4,561 during the 6-year period covered. Those who had no farm planning guidance showed an increase in labor income from $1,551 to $2,623.

Organizing Farms for Maximum Returns From Resources

Some of the stations carry on studies that will help farmers to so adjust operations that they will get more efficient use from their resources. Tobacco farmers in the Coastal Plains of North Carolina with less than 20 acres of cropland learned from the experiment station that net cash incomes could be increased up to 26 percent with a more efficient combination of enterprises and use of resources. On farms with 20 to 29 acres of cropland, net incomes can be increased up to 35 percent over the present level, and on farms with 30 to 39 acres it can be increased 40 percent or more, depending upon the system of farming followed. Because of greater flexibility in their enterprise combinations and economies of large-scale production, the larger size farms could increase their income as much as or more than the groups cited.

Use of Fertilizer To Increase Profit

The Illinois station determined the amounts and combinations of supplemental fertilizers that are most profitable. It showed that there is a need for much larger investments in fertilizers for basic soil treatments of limestone, phosphate, and potash. The New Mexico station calculated that at 1952 prices of alfalfa hay, and assuming the rate of increase in yield of 3.9 tons obtained at the station, the income per acre could be increased $146 above fertilizer costs by fertilizing.

The most efficient citrus production and the highest returns above costs per acre, according to the Florida station, were obtained when 40 to 50 percent of the cash costs went into needed fertilizer materials. Most bearing groves produced at highest efficiency and profitableness with the addition of nitrogen at the rate of 250 pounds per acre or slightly less.

Efficiency in Use of Labor

By using the farm tank system, dairymen can effect substantial savings in handling milk, the Oregon station finds. Savings are largest for farmers producing a large volume of milk, but a farmer with 10 cows can reduce cost approximately $100 a year by installing a farm tank. Savings in labor from 25 minutes to over 1 hour a day are realized, depending upon the number of cans to be cleaned.

In recent years new methods and new equipment for handling manure have been developed but little has been known about relative costs. The Indiana station established that the average cost per ton of handling manure by hand on farms not using power loaders was $1.52. On farms which used power manure loaders to the greatest extent practical and loaded the balance by hand, the average handling cost per ton decreased to $1.20. With labor at 73 cents an hour, a power loader, used with average efficiency, proved economical if over 85 tons of manure were handled annually. The average cost of adapting barns on these farms for use of power manure loaders was $186.

The majority of farmers interviewed in a survey made by the New York (Cornell) station expressed satisfaction with their barn cleaners. Only 4 of the 42 farmers with commercial cleaners expressed

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dissatisfaction and 3 of the dissatisfied owners had units too light for the job. The survey revealed that the cleaners now being installed are less complex than the earlier models. The average cost of commercial cleaners reported was about $1,600, and their average length of life was estimated to be about 9 years. The primary reason for buying cleaners was to make the job easier and to secure and keep good farm help.

Off-Farm Work for Small Farm Owners

Operators of small farms in the Southern Piedmont area of North Carolina can add substantially to their income through off-farm work, the State experiment station (coop. USDA) found. In 1950, families on part-time farms received an average net income of $2,960 compared with $1,575 for families living on other small farms in the area. The part-time farmers received approximately $1,100 net income from farming (taking into account perquisites, inventory changes, and depreciation); a net income of $1,700 from off-farm employment; and $160 from pensions, rentals, and other sources. The small farm operators not classified as part-time farmers had an average of $1,280 net income from farming, $120 from off-farm employment, and $175 from other sources. With better returns in industry, labor is transferring from farm to nonfarm employment at a high rate.

Credit Needs of Farmers

In areas of North Dakota where yields vary considerably from year to year, farmers need credit-repaying schedules better adapted to their fluctuating income, a study conducted by the State experiment station (coop. USDA) revealed. The farmers also needed guidance to help them decide how much security they want; what sacrifice, if any, they are willing to make to enjoy security; and whether this is most likely to be had in a given situation through crop diversification, cultural practices, building reserves, or crop insurance, or by a combination of these.

The Vermont station concludes that it would be possible to invest large additional amounts of capital in improving many local farms, but that quality of farms, the managerial ability of operators, and their financial status often do not justify the lending of capital. It was found that the term of many loans is too short in view of the purposes for which the loans are being used, and that often there is no definite plan for repayment. With the increase in number of cows and the amount of machinery needed for an efficient operation, the amount of short-term credit needed to operate a dairy farm has grown materially. Adequate amounts of short-term credit were found to be available to operators with the managerial ability to use such credit efficiently.

In spite of substantial improvements in the agricultural credit system of Tennessee in recent years, there is still much to be desired. The State experiment station reports that interest rates for production loans range from 6 to 17 percent and that the basis for loan approval is the security of the collateral rather than the productivity of the farm. Although farm owners received 98 percent of their total credit from private and cooperative credit agencies, only 46 percent of the

renters' and 10 percent of the croppers' borrowed funds came from these sources. Credit for intermediate-type investments (2 to 5 years) in livestock, farm enlargement, and soil improvement is generally handled by 1-year-loans, made renewable if conditions remain satisfactory, in cases where real estate is not given as security.

Rental Arrangements

The transfer of property within the family and the question of satisfactory rental or lease arrangements between owner and tenant present complicated problems. The North Carolina station (coop. USDA) in studying rental arrangements as they relate to livestock farms, mechanization, and farm practices, found that practically all existing leases are for 1 year or less, and that livestock production is not a 1-year proposition. Traditional arrangements also were found to be one of the factors that prompts farmers to continue to depend upon annual crops and to disregard mechanization. Tractors and machinery are primarily substitutes for labor and from the landlord's standpoint, mechanization results in increased costs and lower net returns. Since the tenant is reluctant to take a smaller share of the crop, it was concluded that the best solution is for the tenant to own the tractor.

South Dakota landlords rather than their tenants prefer the short 1-year lease, according to information gathered by the State experiment station from 317 farm landlords. Under a share lease, landlords use the 1-year lease to "keep the tenant on his toes." Since they prefer the short-term lease as a bargaining tool with their tenants, it is felt that more research should be conducted with a view to devising a method whereby the share rent may be made more satisfactory to both parties.

The Iowa station reported that although oral 1-year arrangements may result in misunderstandings and difficulties in operating rented lands, 70 percent of the rental arrangements studied were oral and 94 percent were in effect for only 1 year at a time. Seventy-eight percent of the tenants said that they would make needed improvements if they owned the farm, but that with only a 1-year lease they felt they might not receive full benefit. The landlords, on the other hand, were not interested in making improvements from which they did not receive full benefits, as would be the case, for example, with home or livestock improvements under a crop-share or cash lease. Despite these problems, 22 percent of the landlords and tenants had worked out means of making improvements which included long-term leases and automatic renewal of leases subject to 6- or 9-month termination notice by either party. These leases provided for sharing costs and benefits alike, compensating adjustments in leases, improvement rents, and movable improvements and compensation for unused values of improvements.

The Texas station (coop. USDA) concluded from a study of rental arrangements that the essentials of a successful rental agreement for soil-building practices are as follows: (1) An interested landlord and tenant who work together for the mutual benefit of each party; (2) an agreement that will allow the tenant to have possession of the farm in the fall in order to plant soil-building crops; (3) a notice of termination that will enable either the landlord or tenant to make arrange-

ments for the next year; and (4) compensation features that will enable either the landlord or tenant to receive any unused benefits at the termination of the lease.

Prices Received by Farmers

The Kentucky station has shown that since World War II, the price of burley tobacco has averaged about twice that for the 5 years 1935–39, but that the increase has not been similar for all grades. The grades which have risen least are of high quality, bright in color, and in the Flyings and Lugs groups. The grades that have risen most in price are of lower quality, darker color, and are in the Leaf and Tip groups, especially the latter. Indications are that these price changes have been due in large part to technology which has added relatively more value to the lower grades.

Arkansas poultrymen selling eggs to hatcheries were paid an average of 80.7 cents a dozen for hatching eggs during the period July 1, 1950 to June 30, 1951. This price exceeded the average Arkansas market price by 38 cents and the margin varied from a high of 51.2 cents in July to a low of 12 cents in December, according to a State experiment station study. A major problem of hatcheries is that of securing an adequate supply of good quality eggs at the time required. Although some hatcheries reported a surplus of eggs during some of the spring months, there was a deficiency, from the standpoint of the State as a whole, for the period covered by the survey. All but 3 of 110 hatcheries included in the study stated that they had an inadequate supply of eggs.

The Indiana station (coop. USDA) reports that production and the general price level influence the prices of beef cattle most and account for about 70 percent of the total variation in the annual farm price of beef cattle in the United States. With a 10-percent increase in price level, the price of cattle increases about 6 percent. With a 10-percent increase in production, price of cattle decreases about 5 percent. Each of the classes and grades of beef cattle has its own characteristic seasonal price pattern. Choice and prime slaughter steers and heifers usually sell best in the fall and early winter, and good commercial and utility grades sell best in late spring. The highest prices for feeder cattle come rather consistently in the late spring months and lowest prices in the late fall and early winter. Prices of feeder cattle are affected primarily by the price level and the size of the corn crop.

In a study of intergrade and intermarket price differentials for slaughter steers at terminal markets serving Kentucky producers, the Kentucky station found that: (1) Intergrade seasonal price differentials for slaughter steers are smallest in April, May, and June, and largest in the late summer and fall months; (2) intermarket average monthly price differentials for the good grades of slaughter steers between Louisville and four other terminal markets—Indianapolis, East St. Louis, Cincinnati, and Chicago, tends to be wide in the fall and winter and narrow in the late spring and summer; (3) for slaughter steers of the same grade and weight, highest prices were paid on the average at Chicago, followed by Indianapolis, East St. Louis, Cincinnati, and Louisville, in that order.

In a study of prices received for registered beef cattle, the Texas station found that the net farm income exerts an influence on the

prices of these cattle. As net farm income increases, prices of registered beef cattle tend to rise, and as net farm income drops, the decrease is reflected in registered beef cattle prices. There was a greater increase in the prices of registered beef cattle than in the price of land during World War II. However, the purebred cattle boom leveled off much sooner than the land boom. The prices of steers provide an effective floor for the prices of registered beef cattle. The two prices are closely associated during periods of low prices but not during periods of high prices.

A Michigan station (coop. USDA) study of actions taken by Michigan farmers producing eligible crops for price supports in 1949 and 1950, indicates that the age of the farmer, his education, debt status, years of farming, and political inclinations are not associated with the use of supports. Supports were used least for corn and oats and most for field beans and potatoes. Farmers with large farms made much more use of supports than did those with small farms. Among wheat producers, those with over 500 bushels to sell made most use of supports.

The New York (Cornell) station found that the demand for roses at the wholesale level is slightly inelastic, for carnations slightly elastic, and for gladioli near unity. Little difference existed in the demand elasticities of the three flowers, although roses tended to be more of a necessity than carnations. Because of these characteristics, fluctuations in wholesale quantity of these three flowers bring about equal fluctuations in price, with the result that the total dollar volume of wholesale sales varies but little, regardless of supply.

Insurance Needs

In an Indiana station survey of insurance carried by farmers, it was found that many farmers do not have certain types of insurance and others are underinsured. For example, 5 percent carry no fire or wind insurance, 40 percent carry no life insurance, and 75 percent carry no general farm liability insurance. Of those carrying life insurance, the average amount carried was $5,200. Most of the policies, 70 percent, are high cost limited pay life and endowment-type policies. With data obtained on current insurance coverage, an attempt is being made to formulate recommendations on the type and amounts of insurance (fire, life, liability, health, crop, etc.) that farmers should carry to minimize business risks and afford personal and family protection.

The New York (Cornell) station found that the principal causes of fire losses in terms of amount of loss incurred, ranked as follows: Lightning; chimneys and stovepipes; wiring and cords; stoves and furnaces; spontaneous combustion; tractors; sparks, coals, and ashes; smoking and matches; grass fires and incinerators; arson; machinery; and children. The trend was downward in the amount of loss due to chimneys and stovepipes, machinery, and nearby fires; fireplaces, oil lamps, and lanterns; but upward for wiring and cords; stoves and furnaces; spontaneous combustion; tractors; sparks, coals, and ashes; and smoking and matches.

Tax Problems

Unequal tax assessment within townships and counties and between counties exists because of the failure to maintain a constant relation-

ship between assessed value and true or market value, a survey by the Missouri station reveals. Unequal assessments were also found between real estate and personal property and between rural and urban real estate. In some instances part of the property owned by one taxpayer may be omitted whereas a more nearly complete enumeration of the holdings of another may be listed.

From the study it was concluded that better training on the part of assessors would make for greater equity in assessing property. Assessors have not been provided with basic information such as land classification maps, lists of current real estate sales, handbooks on the value of farm equipment and livestock, and other assessment aids. Unequal assessments between types of property result in higher taxes on land in relation to value than on livestock and equipment. Analysis of assessment-sales data shows that the average assessed valuation of farmland is higher than that of town real estate. Incomplete enumeration and low valuation of items listed lead to low assessment of personal property.

RURAL SOCIOLOGY

Rural Population Trends and Migration

During the last decade, Missouri's urban population increased and the rural population decreased, except in areas near cities, according to the State experiment station.

Rural Missouri lost 238,000 people between 1940 and 1950 through migration. Thirty percent of the southeastern rural population left the farm, whereas between 11 and 24 percent moved from other areas. Urban Missouri gained more than 2 percent. Many urban immigrants were young people from rural areas. With the decrease in rural youth population, the death rates of rural areas increased. Urban death rates in 1949 were lower in five of the nine economic areas of the State.

Missouri's rural population was highest about 1900. Its decline since then has been due in part at least to the reorganization of agriculture and other rural industries in the State. Before 1930, industrial prosperity brought country people to the city, relieving a threatened rural population pressure resulting from a high birth rate. Between 1930 and 1940 decline in urban prosperity reduced rural immigration, particularly in the poorer areas of the State. Since 1940 migration from rural areas has more than compensated for the gain through birth.

Many Montana farmers are moving to town to get adequate schooling for their children, the State agricultural experiment station reports. In wheat-farming areas, 15 percent of the farmers maintain a town home for their families while they continue to operate their farms. Farms are growing larger, which reduces the number of families living in rural areas. When some families move, the rural school enrollment drops, the schools close, and other families must move to town. Towns are then forced to provide school facilities for an abnormal increase in enrollment. When some farmers move to town, they dispose of all livestock, thereby jeopardizing the agricultural stability of their farms.

Modern trend in farm communities

Field interviews made by the Washington station indicate that rural neighborhoods are losing their previous significance. Farmers and villagers are now becoming integrated into communities, according to the Wisconsin station. That station has produced figures showing that the number of active rural neighborhoods has decreased about 25 percent in the past 20 years. Three-fourths of those presently active have been so for 30 years. These have certain characteristics. For instance, tenant families do not exceed 28 percent; families resident less than 25 years do not exceed 50 percent; and families of like nationality do not exceed 64 percent. American rural society began on the farm, where families were socially and economically tied together in neighborhood clusters. Village and town centers came later. This arrangement is in contrast with most European and Asiatic settlements, where farmers have for centuries lived in towns and villages and gone out to the surrounding fields.

Labor-deficient areas in cotton production

Cotton harvesting is becoming mechanized in the Texas High Plains, according to State station research on farm manpower, a key factor in the national defense program. Some machine harvesting took place on 91 percent of the sample farms in 1951. The capacity of available machines was adequate for a completely mechanized harvest in the area that year. However, most farm operators preferred to hand-snap the first time over because of losses in cotton quality and yield that occur in machine harvesting. Tenure arrangements and small units also retard the use of machinery. Until these difficulties are removed, total mechanical harvesting of the cotton crop will not materialize.

Twenty percent of the labor used in cotton operations was local, the rest was migratory. Only 3 percent of the operators sampled used Mexican Nationals in 1951. However, Mexico has a substantial farm labor potential in case of a U. S. manpower crisis. Seventy-six percent of the labor was recruited by the operator, or sought work from him; 17 percent was obtained through arrangements made the previous year; and 7 percent was recruited through the Farm Labor Office. Thirty-two percent of the labor was lost before the end of the harvest through dissatisfaction with wage rates, poor fields, and necessity of insuring schooling for children. Less than 1 percent left because of poor housing.

For 1952, 50 percent of the operators thought they would make no adjustments to meet the labor situation; 23 percent planned to buy strippers; 11 percent intended to depend more on imported labor; 7 percent planned to contract for additional custom stripping; and 9 percent expected to reduce cotton acreage.

Educational, Health, and Counseling Needs

Adult classes for farm instruction

In a survey of veterans who had taken part in the GI training program the Washington station learned that many had received their on-the-farm training on farms requiring supplemental income. The

program failed to provide enough training for veterans who wanted to become fulltime farm operators. Most of them were favorably impressed with the idea of such adult training programs, however, and made constructive suggestions for improvements. The findings suggest that a well-designed program of adult agricultural instruction in the classroom would attract many veterans who have exhausted their GI benefits and that many nonveterans might be attracted by such a program.

Rural libraries in Utah

The Utah station has found that libraries have been important factors in the growth of the State's culture. However, there is a great variation in the growth of library buildings and equipment, in the number of books and facilities acquired, in the effectiveness of their organization and in the degree to which they have been integrated into the community. In two of the four counties studied, rural library organization was equal or superior to that found in the best urban libraries. However, some communities had no libraries, and others had inferior service.

Sources of farmers' information

The Kentucky station found that farmers in the State obtained agricultural information from the following sources: Neighbors, friends, or relatives (88 percent); radio (86 percent); farm magazines (77 percent); circular letters from county agents (76 percent); newspapers (67 percent); conferences with professional agricultural advisers (57 percent); farm bulletins (46 percent); farm meetings and demonstrations (33 percent); and dealers and businessmen (31 percent).

Radio, neighbors, friends, and relatives were cited as "most helpful," although conferences with agricultural advisers, farm meetings, demonstrations, and bulletins were more effective when used. One in 10 farmers had received no direct help or information during the previous 2 years from any of the agricultural agencies operating in the county. Three in 10 reported help from 3 or more agencies.

Health and medical care of rural families

The Indiana station studied the health and medical care of 603 rural families representative of the population of three counties. Results showed 60 percent had not been to a dentist during the 6 months prior to the survey. Five percent had used fluoride treatment. One family in three carried hospital insurance, two families in three favored such insurance. Over 90 percent who desired hospitalization obtained admission when wanted. Four in five hospitalized were satisfied with the accommodations and the treatment received. One in ten of the families interviewed drank water from a spring or dug well. Others used a drilled well or had connections to a public water system. Only one in five families using private water had it tested for impurities.

The needs of youth in rural Louisiana

Research conducted at the Louisiana station shows that older rural youth (between 15 and 30) need information and guidance. The

older youth population in the rural-farm areas is decreasing so rapidly as to arouse concern about the future Louisiana rural scene. More of these young people live in rural nonfarm areas than in rural farm areas. Youth living on the farm are younger on the average than youth living in nonfarm areas. There are a large number of nonwhites among the State's older youth population. Older youth feels a keen need for a more complete social life, including programs of education and recreation. These young people face a period when they must make many decisions; they are leaving the family group, finding jobs, establishing homes, and accepting the responsibilities of citizenship. They are in need, therefore, of guidance and counseling.

Leadership and Community Success

Land authority communities in Puerto Rico

The Commonwealth of Puerto Rico has established certain land authority (resettlement) communities to help farmers improve their agricultural production and economic status. The Agricultural Experiment Station of the University of Puerto Rico conducted research on the sociological aspects of six of these communities representing three specialized agricultural regions. Communities diminished in success from the sugarcane region to the tobacco and minor-crop areas and to the coffee-growing region. Two groups were studied in each community, the parcineros (partners or copartners) and the agregados (farm laborers, assistants). The occupational status of the agregado had a direct bearing upon his level of living, whereas the occupational status of the parcinero did not. Professional leaders in successful communities were very effective in stimulating natural leadership.

When communities were resettled, members were usually highly satisfied. There was an overwhelming change in the state of mind of the agregado once he had the experience of being a parcinero. Although the parcinero in a successful community had a higher income than the parcinero in a unsuccessful area, his relative status within the community was similar. Parcineros in successful communities came from shorter distances and selected leaders within their group, whereas parcineros in unsuccessful communities came from greater distances and looked for leaders outside their boundaries. Successful communities were more aware of those who were their leaders than unsuccessful communities. Communities highly integrated in formal groups and recreational participation were most successful.

AGRICULTURAL ENGINEERING

Many new developments continue to be reported by the agricultural engineering departments of State experiment stations. These range from new instruments used in carrying on specialized fields of research to devices that save labor and aid operations on the farm, in processing plants, and in the various channels of farm produce distribution. A few examples follow.

Photoelectric Meter for Color-Grading Tomatoes

Commercial lots of tomatoes and other vegetables and fruits sold for processing are customarily contracted for according to established

color grades (in which color is regarded as an important factor). The Indiana station has developed a compact, portable photoelectric color meter that rapidly measures and records color pigments present in raw and processed fruits and vegetables. The meter separates and measures the amount of yellow and red light reflected from a band approximately 1 inch wide around the equator of the raw fruit or of a transparent container holding processed fruit. The reading indicates the degree of ripeness of the product under test. The new instrument has shown such accurate recordings in pilot runs that it is expected to play an important part in the future grading of tomatoes and other products sold for commercial processing.

The "Thermoresistometer," a New Research Tool

The development of a new research instrument designed to study the heat resistance or thermodestruction of bacterial spores causing canned food spoilage and loss of heat-labile vitamins has been reported by the Massachusetts station.

The instrument, known as "Thermoresistometer," makes possible the aseptic treatment of open metal cups containing materials under study. The basic part of the apparatus is a steam chamber to which is attached a set of six double-acting pneumatic cylinders equipped with pistons which carry the samples. A sterile antechamber is provided where both sample loading and subculturing is done. Compressed air moves the piston with its sample cup into the steam chamber for the predetermined time and then removes it. Temperature is maintained within exacting limits under the range from 215° to 300° F. and exposure time may be varied from 0.3 seconds to 20 minutes.

Approximately 30,000 test samples have been run satisfactorily on the machine. Its practical value for studying the reaction rates of samples of any chemical compound within its temperature range has been clearly demonstrated.

An Instrument To Measure Cotton Fineness

Using established knowledge with respect to the flow rates of air through porous mediums, the research personnel of the Tennessee station have developed a new scientific instrument that quickly and accurately measures fineness of cotton fiber. The machine has been given the name "arealometer."

A weighted amount of cotton sample is placed in a cylinder of known cross-sectional area where it is compressed until its resistance to flowing air is equal to a known standard value. Coarse cotton fibers must be compressed more than finer ones to give the same air flow rate.

The piston that compresses the cotton plug is calibrated to give a direct reading of specific area from which the measurement of fineness of the sample is determined. The apparatus can also be used to measure the immaturity of cotton. The fineness reading is taken while the cotton sample is loosely packed and again after it has been highly compressed. The difference in the two readings is converted to stage of maturity with the aid of a specially prepared conversion chart.

Instruments To Measure Potato Toughness

The North Dakota station has developed three instruments that are expected to reduce by several years the time required to study the storage qualities of potato varieties developed in the breeding program, also to determine the optimum time of digging, the safe storage depths, and the type of handling equipment that can be used safely for different varieties. The three instruments can be used to measure, respectively, three type of bruises classified as pressure, abrasion, and impact. The pressure machine can tell the safe storage depth for a certain variety or batch of potatoes; the abrasion machine reveals how easily the potatoes will skin; and the impact machine predicts the safe distance to drop potatoes into the bin.

Stone Picker Built From Potato Digger

Potato soils in some of the major potato-producing areas, particularly Maine, are stony. The stony soils prevent potato growers from using bulk harvesting methods and make it necessary for them to use large amounts of hand labor in harvesting potatoes.

Agricultural engineers have successfully used a standard potato digger, equipped with a conveyor attachment, for delivering the rocks directly into a truck box bed for removal from the field. Comparisons indicate that the modified digger is equal to or superior in performance to commercially built rock pickers.

The use of the rock picking machine to clear potato fields of stones will pave the way for the development and introduction of bulk harvesting machinery that would reduce production costs. The rock picking machine was developed from machinery on the farm in an effort to hold farming costs down. Growers can cheaply and easily convert their potato diggers for rock picking purposes.

New Ridging Device for Corn Production

A ridging device for use in determining the effects and advantages of growing corn on a ridge rather than in the conventional furrow is being developed by the Iowa station. It is a modified lister which makes two evenly spaced ridges about 42 inches apart across the field. Seed corn is planted into the warm soil on top of the ridges. Still in the experimental stage, the new method prevents losses of plants by flooding and also covers up less corn during the first cultivation. Corn growth appears to exceed weed growth, particularly when some of the pre-emergence weed sprays are used. In the Iowa experiments corn planted on the ridge gave yields in normal years as good as corn planted in other ways. In years when heavy rains and standing water cause losses, ridge-planted corn is expected to yield better.

Mechanical Sugar Beet Weeder and Thinner

The Michigan station (coop. USDA) developed a new sugar beet thinning and weeding device whereby one machine operation can be eliminated and the amount of hand labor required for growing the

crop can be reduced. The machine, mounted on the tractor tool bar, is built for down-the-row operations. Two power-take-off-driven, spring-tined wheels or heads rotating in opposite directions to each other and at right angles to the row are used to thin and weed the crop. The rotating tines and the forward travel of the tractor causes an X-shaped pattern to be cut in the row. Depth of penetration of the rotating tines is accurately controlled by a gage wheel which runs directly over the beet row. Adjustment of the machine to fit the ground profile in the row is accomplished through a mechanical linkage arrangement.

Machine Processing of Pandanus Leaves

The Hawaii station developed a small power-driven machine for flattening, softening, and cutting the leaves of the Pandanus plant into strips suitable for weaving into articles such as baskets, hats, or table and floor mats. The machine contains knives which are adjustable so that strips varying in width from $\frac{1}{16}$ to $2\frac{1}{2}$ inches can be obtained. With three operators, the unit can handle up to 200 leaves per hour. The machine reduces labor costs by as much at 40 percent. It has substantially increased the amount of strips available to local artisans.

Hedging Machine for Citrus Groves

The Florida station reports the development of a mechanical device for hedging or pruning citrus trees. This annual hand operation consists of cutting back the trees vertically to provide an aisle 6 to 8 feet wide for sunlight to enter and for trucks and grove equipment to maneuver without damage to either trees or equipment. The machine consists of a series of 12-inch overlapping circular saws on mandrills mounted in a vertical line to a 6-inch channel iron support. The saws are driven at approximately 3,000 revolutions per minute by a stationary gasoline engine through a series of V-belts.

In operation the saw column and power unit is mounted on a flat bed truck or trailer and is slowly moved in a straight line down the row of trees at a speed around 1 mile per hour. Tests have shown that the machine will cut out a grove in approximately one-tenth the time it would take using the conventional hand shear method.

Rubber-Paddled Stripper Rolls Reduce Cotton Harvest Losses

Approximately 20,000 cotton-stripping machines, most of which use some type of roller as a stripping mechanism, are being used by cotton farmers. Field losses in stripping open boll varieties with these machines is often excessive. To overcome such damage, the Texas station developed a rubber-paddled stripper roll. A pair of the new rolls was tested for comparative performance with conventional steel rolls of the same size and with tampico fiber brush rolls. The rubber-paddled roll gave the highest performance of the three types when tested on several varieties of cotton having a wide range of plant and boll characteristics.

Mechanical Harvesting of Green Asparagus

Mechanization of green asparagus harvesting has become economically feasible, the California station reports. The set-level cutting principle is used in a new experimental model developed by the station. The asparagus spears are cut at a preset fixed level below the bed surface and the crop should be planted flat for proper operation of the machine. Actual cutting is accomplished through the use of a band saw type of blade with half-moon-type scallops as a cutting edge. This blade runs approximately ½ inch below the surface of the bed and at a blade speed of 5,000 feet per minute.

In operation a series of sponge rubber protected gripper-units and pickup rings, each of which cover 2½ inches of row width, grips and holds the spears before they are cut. As the moving blade severs the spears from the plant, the pickup assembly rotates and at a predetermined position drops the individual spears butt end first onto a conveyor belt. The conveyor deposits the spears into a V-shaped hopper in which they are oriented with all the butts in the same direction.

Normal operating speed of the unit is 2½ miles per hour. The entire harvesting assembly, consisting of frame, pickup units, band saw and pulleys, and conveyor and hopper, is a unit that can be attached to the rear of a wheel-type tractor. A gage roller at the rear of the machine controls the depth of cut below the surface of the planting bed for the band saw blade.

Hill-Drop Planter Improvement

The Oklahoma station has developed a trajectory seed tube for use on hill-drop planters that make mechanized hill planting of cotton to a stand more practical than drilling. This new tube overcomes clogging of seed at the neck of the conventional planter tube heretofore used. Several large implement manufacturers are changing the design of their planters and are incorporating the new trajectory tube in it. Thus cotton farming has moved another step closer to complete mechanization.

Supplemental Irrigation

Supplemental irrigation can bring about a large increase in forage production. At the Illinois station in 1952 the measured rainfall was 16.6 inches from May through October. The addition of 21 inches of irrigation water to ladino clover pasture increased the forage yield by 105 percent. This increased the cattle stocking rate by 100 percent and produced animal gains 77 percent higher than those on the unirrigated pasture.

The Indiana station also found that irrigation of first-year ladino-bromegrass-timothy pasture gave very high increases in yield. Both the July and August harvests on the irrigated pasture were above 1,500 pounds per acre, whereas the nonirrigated pasture produced only 100 pounds in August.

Although Maine has between 35 and 40 inches annual precipitation, research shows that irrigation, particularly with blueberries, corn, beans, potatoes, and pastures for dairy cattle increases production

markedly. During the month of July, available moisture is usually low, and summertime dry periods that reduced crop yields have been recorded in about 1 out of every 2 years.

The irrigation is distinct from that in the more arid Western States. Water is usually close by; the application of water is a matter of careful timing since it is supplemental; and the distribution is not on an extensive basis as in the West.

Increases in crop yields per acre have been measured as follows: Potatoes, 126 bushel increase; blueberries, 50 bushels as compared to complete failure; sweetcorn, 10,622 pounds; and beans, 2,300 pounds.

The 4-day average of herd production of milk prior to going on the pasture was 6,396 pounds. The 4-day herd average while on the irrigated pasture was 6,703 pounds, an increase of 307 pounds for the 4 days. The response to pasture irrigation was obtained during August when pastures normally are drying up. This research shows that, by using irrigation, milk production can be kept up during the period when milk is in demand by the summer trade in Maine and while the supply is normally tapering off to the November low point.

New Spray Equipment for the Helicopter

The development of new aerial spray equipment for use on helicopters is reported by the Connecticut station (coop. USDA). This apparatus makes possible the delivery of sprays of any droplet size, and since spray materials are continuously mixed, and larger nozzles are used, suspension-type sprays can be applied. These kinds of sprays were not possible with former equipment for they clogged the fine screens and nozzle heads and presented a spray drip problem.

Spray materials are carried in two 25-gallon tanks. A centrifugal pump supplies the material to nozzles where it is atomized by the air blast from the fan used to cool the engine. Higher velocity atomization when required is accomplished by adding the air blast from the exhaust of the helicopter engine. The helicopter rotor drives the spray downward at a rate of 12 to 20 miles per hour.

Bailing Hay for Drying With Forced Air

The Michigan station has shown that the secret of proper curing of high-moisture hay lies in making the bales less dense so that air can be readily forced through them. Tightly packed, dense bales cannot be satisfactorily cured if the moisture content of the hay in the bales exceeds about 25 percent. In the Michigan experiment high-quality baled hay was produced by forced-air drying, even though the moisture content of the hay was as high as 40 percent when it went into storage.

Grain Drying

Reliable estimates of the losses that occur to farm-stored crops indicate that every year ⅛ to ¼ of the amount placed in storage is lost. Nearly all of this damage and resulting loss except that caused by rodents, can be traced directly to excessive moisture in the grain. The Nebraska station reports that grain can be dried prop-

erly and economically by the forced circulation of unheated air through the grain after it has been placed in bulk storage bins. Oats have been dried to a safe storage moisture content for ½ cent per bushel, wheat for less than 1 cent per bushel, and shelled corn with an initial moisture content of 32 percent for less than 3 cents per bushel. The North Dakota station reports that wheat with 16- to 20-percent moisture content can be dried to 14 percent at a cost of less than 1 cent per bushel. Under the climatic conditions in North Dakota, unheated air is the most practical. A blower installed on a main duct connected to a series of laterals on the floor of the grain bin forces air through the damp grain until it is dry.

Studies by the Alaska station pertaining to the storage of barley at various levels of moisture show that germination is adversely affected when moisture level is about 16 percent. Using a batch-type grain drier with a 6-inch column thickness, barley was reduced from 29 percent to 13 percent moisture with a fuel cost of $3.40 per ton and an electric power cost of 23 cents per ton.

More Economical Drier Operation

Intermittent blower operation controlled by a humidistat was found by the Maryland station to be just as good as continuous operation, in drying newly harvested corn. The intermittent method was even more effective during the later stages of drying. Its use reduced power cost by one-half.

Low-Cost Wood-Treating Plant

The Minnesota station has announced the development of a new type process for applying wood preservative which provides a relatively good treatment at a low plant cost.

The unit utilizes the principles of a vacuum process wherein air is withdrawn from the wood being treated and is replaced by the preservative solution. This new operation fills the need for a process which is less expensive than that used by large commercial treating units and does a better job than the ordinary cold-soak dip method commonly used by farmers. Capacity of the new plant per unit treatment is one hundred 3-inch fence posts or 1,000 board-feet of sawed lumber.

End-Joining Method Developed To Salvage Lumber

The Alabama station has developed a method for making a high-strength, glued-end joint out of short pieces of lumber. Tests of the new joint, when broken in the center, showed that it had an average strength of from 75 to 80 percent of that of clear wood. The process developed by the Alabama Station will make it possible to join short boards into long ones and then edge-glue them into wide panels, from which commercial laminates of standard form can be manufactured. It provides an excellent means of salvaging lumber formerly burned or otherwise scrapped at lumber mills.

STATISTICS—PERSONNEL, PUBLICATIONS, INCOME, AND EXPENDITURES

Personnel and Publications

The research personnel of the experiment stations in 1953 included 3,461 staff members devoting full time to station research and 4,016 who divided time between research and teaching or extension work. The total in both categories, 7,477, represented an increase of 201 over the total of 1952.

Printed publications of the experiment stations in 1953 included 811 bulletins, circulars, and reports; 5,229 articles in scientific journals; and 551 miscellaneous publications. In addition, 709 popular and 859 technical reports, bulletins, and circulars were processed by the stations.

Data by individual States relating to personnel and publications are shown in tables 1 and 2.

Income and Expenditures

Appropriations under the authorizations of the Hatch, Adams, and Purnell Acts for use by the experiment stations in 1953 totaled $4,577,500, each State, Hawaii, and Puerto Rico receiving $90,000 and Alaska $77,500. A total of $2,863,708 was appropriated under title I, section 5, of the Bankhead-Jones Act of June 29, 1935, with allotments to the individual States, Hawaii, Alaska, and Puerto Rico as shown in table 3. These allotments are made primarily on the basis of rural population adjusted in accordance with the provisions of the Department of Agriculture Organic Act of 1944. The total amount of Federal-grant funds appropriated to this Office under the Hatch, Adams, and Purnell Acts, and title I, section 5, of the Bankhead-Jones Act, was $7,441,208.

Under title I, section 9, of the Bankhead-Jones Act $5,000,000 was appropriated. Of this total $150,000, authorized by section 9 (c) of the act, was available to the Office of Experiment Stations for administration. Of the remainder $3,600,000 was allotted to the States, Hawaii, Alaska, and Puerto Rico, under the formulas described in sections 9 (b) (1) and (2); $1,250,000 was available for allotment to the States for cooperative regional research projects authorized by section 9 (b) (3) and for travel by the Committee of Nine established in accordance with this section. The amounts allotted under sections 9 (b) (1), (2), and (3) are shown in table 3.

In addition to the Federal-grant funds enumerated above, the Office received funds from the Agricultural Marketing Act (Title II, Research and Marketing Act) for allotment to the State agricultural experiment stations for marketing research. Allotments totaling $255,200.00 were made to the stations during the fiscal year 1953 (table 3).

Non-Federal income of the stations appears in table 4.

Expenditures of Federal-grant funds are shown under object classes by individual experiment stations in table 5, 6, 7, 8, 9, and 10; expenditures of non-Federal funds are indicated in table 11. The 1953 expenditures of non-Federal funds which include State appropriations, research grants, and income from other sources totaled $61,970,921.10, as compared with $56,883,853.97 in 1952. The 1953 non-Federal fund expenditures by all of the stations approximated $5.05 for each $1 of Federal grants. Summaries of expenditures appear in tables 12 and 13.

Expenditures and allotments of funds from the Agricultural Marketing Act are shown in table 14.

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TABLE 1.—*Organization and personnel of the experiment stations for the year ended June 30, 1953*

Station	Date of legislative assent to Hatch Act	Date of organization under Hatch Act	Personnel				
			Full-time research	Research and teaching	Research and extension	Research, teaching, and extension	Total research workers
			Number	*Number*	*Number*	*Number*	*Number*
Alabama	Feb. 27, 1889	Apr. 1, 1888	66	56		2	124
Alaska	May 2, 1929	May 1, 1931	21	4		1	26
Arizona	Mar. 19, 1889	July 1, 1889	35	42	1		78
Arkansas	Mar. 7, 1889	Apr. 2, 1888	48	52	1	1	102
California	Mar. 12, 1889	Mar. 13, 1888	126	344			470
Colorado	Mar. 25, 1889	Feb. 20, 1888	49	80		3	132
Connecticut:							
State	May 18, 1887	May 18, 1887	72				72
Storrs	do	Apr. 1, 1888	34	38	3	9	84
Delaware	Apr. 14, 1887	Feb. 21, 1888	20	16	7	4	47
Florida	June 7, 1887	Mar. 16, 1888	174	31	5	4	214
Georgia	Dec. 24, 1888	Feb. 18, 1888	132	58	2	13	205
Hawaii	Mar. 31, 1911	July 1, 1929	42	18	2	1	63
Idaho	Jan. 23, 1891	Feb. 26, 1892	29	42	1		72
Illinois	May 11, 1887	Mar. 21, 1888	96	116	12	3	227
Indiana	Jan. 19, 1889	July 1, 1887	111	92	23	14	240
Iowa	Mar. 1, 1888	Feb. 17, 1888	80	130	26	21	257
Kansas	Mar. 3, 1887	Feb. 8, 1888	47	167	1		215
Kentucky	Feb. 20, 1888	Apr. 29, 1888	101	33	5	11	150
Louisiana	July 12, 1888	Apr. 5, 1887	115	57	1		173
Maine	Mar. 16, 1887	Feb. 16, 1888	32	32	1	1	66
Maryland	Mar. 6, 1888	Mar. 9, 1888	17	37	6	27	87
Massachusetts	Apr. 20, 1887	Mar. 2, 1888	84	16			100
Michigan	Apr. 12, 1889	Feb. 26, 1888	92	125	11	7	235
Minnesota	Feb. 4, 1889	Jan. 26, 1888	33	156	5	4	198
Mississippi	Jan. 31, 1888	Spring, 1888	91	54		3	148
Missouri	June 11, 1889	Jan. 31, 1888	21	120	3	3	147
Montana	Feb. 16, 1893	July 1, 1893	55	56	1	13	125
Nebraska	Mar. 31, 1887	June 14, 1887	70	74		1	145
Nevada	Feb. 8, 1889	Dec. —, 1887	15	7		5	27
New Hampshire	Aug. 4, 1887	Feb. 22, 1888	17	40	4	4	65

New Jersey	Mar. 16, 1887	Mar. 5, 1888	84	66	2	2	154
New Mexico	Feb. 28, 1889	Nov. 14, 1889	34	28	1	3	66
New York:							
Cornell	Mar. 30, 1887	Apr. 30, 1888	33	132	20	43	228
State	[1]		71				71
North Carolina	Mar. 7, 1887	Dec. 5, 1889	91	109	1	4	205
North Dakota	Mar. 8, 1890	Oct. 15, 1890	37	39			76
Ohio	Mar. 16, 1887	Apr. 2, 1888	96	70	1	3	170
Oklahoma	Oct. 27, 1890	Aug. 14, 1891	58	95	4	1	158
Oregon	Feb. 25, 1889	July 2, 1888	122	93	4	3	222
Pennsylvania	June 3, 1887	June 30, 1887	1	217		2	220
Puerto Rico	Aug. 16, 1933	Nov. 14, 1935	91				91
Rhode Island	Mar. 31, 1887	Nov. 3, 1888	20	14	2	7	43
South Carolina	Dec. 22, 1887	Jan. —, 1888	89	23	2	1	115
South Dakota	Mar. 11, 1887	Nov. 17, 1887	36	50		1	87
Tennessee	Mar. 29, 1887	July 24, 1887	107	40	1	8	156
Texas	Apr. 2, 1887	Jan. 25, 1888	198	74	3	15	290
Utah	Mar. 8, 1888	Nov. 6, 1889	45	63	1	4	113
Vermont	Nov. —, 1888	Feb. 28, 1888	7	23	4	13	47
Virginia	Feb. 29, 1888	June 13, 1888	82	33	5	8	128
Washington	Mar. 9, 1891	May 1, 1891	118	69		1	188
West Virginia	Feb. 22, 1889	June 11, 1888	16	56	1	3	76
Wisconsin	[2]	July 1, 1887	72	111	4	22	209
Wyoming	Jan. 10, 1891	Mar. 27, 1891	28	38	2	2	70
Total			3,461	3,536	179	301	7,477

[1] First made eligible to receive part of the State allotment of Federal funds by legislative act approved May 12, 1894.
[2] Session of 1887.

TABLE 2.—*Publications issued by the agricultural experiment stations during the fiscal year ended June 30, 1953*

Station	Printed publications																Processed publications			
	Reports, bulletins, and circulars				Articles in journals				Periodicals				Pamphlets, leaflets, etc.				Reports, bulletins, circulars, etc.			
	Pop.	Tech.	Pages	Copies	Pop.	Tech.	Pages	Copies reprinted	Pop.	Tech.	Pages	Copies	Pop.	Tech.	Pages	Copies	Pop.	Tech.	Pages	Copies
Alabama	3	7	512	51,000	------	72	352	6,450	------	------	------	------	5	------	26	32,000	51	------	296	25,000
Alaska	5	------	70	15,000	------	7	(1)	(1)	------	------	------	------	3	------	(1)	(1)	------	8	175	900
Arizona	10	2	617	37,200	------	20	100	----------	4	------	48	40,500	------	------	------	------	------	2	82	1,250
Arkansas	3	10	393	45,500	------	18	68	----------	3	------	24	22,700	------	------	------	------	4	------	43	6,500
California	21	7	1,180	386,250	335	733	14,335	----------	12	8	582	434,296	9	1	100	150,000	------	33	1,365	14,075
Colorado	7	------	152	50,000	------	28	336	5,600	2	3	94	155,000	1	------	1	1,000	31	------	372	18,600
Connecticut:																				
State	5	12	626	70,100	39	78	540	----------	2	------	16	24,000	------	------	------	------	4	------	24	2,230
Storrs	------	24	460	34,700	------	43	252	13,550	4	------	12	9,000	------	------	------	------	------	------	------	------
Delaware	2	3	84	6,500	------	29	136	----------	3	10	132	700	3	9	165	7,806	------	------	------	------
Florida	------	31	1,067	357,000	117	221	916	----------	------	------	------	------	------	------	------	------	------	------	------	------
Georgia	11	21	939	117,100	10	44	169	----------	4	------	16	37,000	------	------	------	------	39	------	317	40,750
Hawaii	8	4	375	25,800	------	18	134	----------	4	------	32	10,000	------	------	------	------	------	------	------	------
Idaho	16	3	326	114,100	------	13	76	----------	4	------	32	60,000	------	------	------	------	9	------	68	18,000
Illinois	4	15	880	204,600	------	191	1,254	----------	------	24	124	77,400	------	------	------	------	3	57	603	22,580
Indiana	16	11	860	169,500	------	106	634	----------	------	2	10	1,200	------	------	------	------	41	10	223	168,995
Iowa	2	9	708	68,645	------	137	1,096	45,125	12	------	232	260,500	69	------	284	62,000	18	------	283	15,525
Kansas	19	1	682	121,500	42	174	1,016	33,425	------	------	------	------	2	------	17	15,000	138	64	2,272	543,673
Kentucky	2	18	824	104,300	49	34	422	----------	------	------	------	------	------	------	------	------	14	------	402	19,425
Louisiana	------	14	663	59,500	------	81	343	----------	------	4	32	20,000	------	------	------	------	3	77	1,126	52,325
Maine	2	14	360	52,700	------	13	34	----------	4	------	24	7,300	2	4	145	11,400	------	7	55	3,250
Maryland	3	2	313	10,000	------	62	------	1,550	------	------	------	------	------	------	------	------	------	15	480	(1)
Massachusetts	------	8	336	22,700	------	40	225	8,450	2	12	84	15,100	------	------	------	------	------	------	------	------
Michigan	8	6	626	53,179	------	107	635	----------	4	------	518	9,600	------	------	------	------	------	------	------	------
Minnesota	6	7	420	105,500	------	197	1,296	----------	3	------	60	49,500	3	------	52	20,500	------	14	381	10,750
Mississippi	24	3	655	104,000	------	67	(1)	----------	12	------	96	456,000	16	------	32	30,000	3	------	343	1,500
Missouri	17	23	1,356	135,200	------	48	(1)	----------	12	------	108	312,000	52	------	52	104,000	------	------	------	------
Montana	10	2	432	66,500	------	26	171	----------	------	------	------	------	------	------	------	------	9	------	377	4,500
Nebraska	7	3	286	43,000	------	49	(1)	----------	4	------	64	38,000	19	------	38	38,000	26	------	284	47,000
Nevada	1	------	11	2,500	------	------	------	----------	------	------	------	------	------	------	------	------	2	------	14	5,000
New Hampshire	------	8	267	38,100	------	10	68	----------	------	------	------	------	------	------	------	------	4	------	37	2,400

New Jersey	7	8	236	65,750	------	90	585	----------	6	12	1,066	95,500	11	------	160	36,425	4	------	22	25,000
New Mexico	11	------	320	43,400	------	6	41	1,200	------	------	----------	----------	------	------	----------	----------	14	------	169	12,600
New York:																				
Cornell	------	30	1,324	132,950	------	632	2,639	----------	4	------	64	100,000	------	------	----------	----------	------	201	3,312	(1)
State	------	6	213	27,200	------	15	64	2,500	4	------	64	105,000	1	------	6	2,000	47	------	138	9,400
North Carolina	5	4	450	58,000	------	57	450	----------	3	------	48	18,000	------	------	----------	----------	16	15	401	19,385
North Dakota	9	1	476	52,500	------	83	392	----------	6	------	264	44,500	2	------	4	8,000	18	39	592	35,116
Ohio	4	26	922	137,300	------	67	450	3,250	6	------	116	122,000	33	2	112	7,000	------	222	782	70,375
Oklahoma	22	2	380	104,500	10	68	205	(1)	6	------	124	18,000	24	------	370	78,751	19	------	141	26,625
Oregon	17	5	638	118,500	------	45	(1)	(1)	4	------	40	3,200	------	------	----------	----------	24	------	155	50,100
Pennsylvania	28	16	841	145,500	6	48	344	----------	3	------	36	36,000	------	------	----------	----------	------	8	175	5,350
Puerto Rico	------	8	565	24,000	------	19	74	----------	------	8	574	24,000	11	------	119	11,000	------	------	----------	----------
Rhode Island	4	4	254	14,357	------	13	44	1,450	------	------	----------	----------	3	------	6	19,000	------	12	115	180
South Carolina	------	13	647	75,000	2	15	54	----------	------	------	----------	----------	------	------	----------	----------	15	13	116	10,190
South Dakota	11	2	443	107,000	------	27	132	----------	4	------	104	20,800	2	------	32	4,000	22	------	645	5,885
Tennessee	6	5	142	58,500	15	41	336	----------	4	------	48	12,000	------	------	----------	----------	------	2	40	2,500
Texas	13	5	696	90,000	------	154	612	----------	------	------	----------	----------	10	1	188	50,000	112	1	455	561,000
Utah	11	------	290	32,000	------	20	113	----------	4	------	100	26,000	1	------	15	1,000	------	16	232	5,900
Vermont	4	1	172	12,500	2	5	39	----------	------	------	----------	----------	2	1	16	7,526	1	2	29	950
Virginia	9	1	344	40,200	------	----------	----------	----------	------	------	----------	----------	1	------	4	2,000	------	----------	----------	----------
Washington	------	10	436	34,500	------	105	743	27,075	------	------	----------	----------	------	8	166	5,650	------	40	671	66,050
West Virginia	5	2	284	36,050	------	12	55	24,000	4	------	44	24,000	------	------	----------	----------	4	------	38	10,000
Wisconsin	5	1	379	57,500	------	365	(1)	(1)	------	------	----------	----------	------	------	----------	----------	2	------	15	22,000
Wyoming	6	4	277	34,600	------	19	61	(1)	4	------	64	32,000	------	------	----------	----------	12	1	103	11,900
Total	389	422	27,209	4,173,431	627	4,602	32,041	173,625	157	83	5,096	2,720,796	285	26	2,110	704,058	709	859	17,968	1,974,734

[1] Total unknown.

TABLE 3.—*Federal funds available to the experiment stations for the year ended June 30, 1953*

Station	Federal-grant funds [1]					Contractual Federal funds, Agricultural Marketing Act, title II			Total Federal funds available
	Hatch, Adams, and Purnell [2]	Bankhead-Jones, title I			Total	Carryover from 1952	1953 allotment	Total	
		Sec. 5	Secs. 9 (b) 1 and 9 (b) 2	Sec. 9 (b) 3					
Alabama	$90,000	$88,305.89	$110,950.58	$20,810	$310,066.47				$310,066.47
Alaska	77,500	4,736.40	21,897.67		104,134.07				104,134.07
Arizona	90,000	16,740.68	31,555.29	26,750	165,045.97				165,045.97
Arkansas	90,000	66,187.20	92,079.58	19,300	267,566.78				267,566.78
California	90,000	102,716.44	100,038.22	39,550	332,304.66		$11,700	$11,700.00	344,004.66
Colorado	90,000	25,460.16	41,704.57	35,850	193,014.73				193,014.73
Connecticut:									
State	45,000	11,257.19	16,860.10	3,000	76,117.29				76,117.29
Storrs	45,000	11,257.19	16,860.09	17,300	90,417.28	$241.74	4,960	5,201.74	95,619.02
Delaware	90,000	5,970.02	24,223.68	2,500	122,693.70				122,693.70
Florida	90,000	48,046.76	54,516.46	12,900	205,463.22	1,811.96	3,800	5,611.96	211,075.18
Georgia	90,000	98,402.95	114,822.94	44,850	348,075.89	4,972.10	11,480	16,452.10	364,527.99
Hawaii	90,000	10,463.17	29,104.17	5,000	134,567.34	3,561.23	3,440	7,001.23	141,568.57
Idaho	90,000	16,866.19	36,317.72	17,700	160,883.91				160,883.91
Illinois	90,000	99,478.95	106,078.66	30,620	326,177.61	2,795.20	3,190	5,985.20	332,162.81
Indiana	90,000	79,141.32	91,911.36	50,150	311,202.68	927.22	17,620	18,547.22	329,749.90
Iowa	90,000	74,227.20	93,449.77	59,770	317,446.97	676.83	21,160	21,836.83	339,283.80
Kansas	90,000	53,057.23	64,482.24	19,550	227,089.47	2.45	10,000	10,002.45	237,091.92
Kentucky	90,000	93,378.88	114,798.45	6,900	305,077.33				305,077.33
Louisiana	90,000	60,813.78	78,146.78	20,050	249,010.56				249,010.56
Maine	90,000	22,270.68	36,916.75	22,900	172,087.43		7,500	7,500.00	179,587.43
Maryland	90,000	36,488.62	46,382.51	19,750	192,621.13	2,043.97	4,470	6,513.97	199,135.10
Massachusetts	90,000	36,698.19	41,538.49	12,450	180,686.68		4,000	4,000.00	184,686.68
Michigan	90,000	93,777.64	100,436.14	20,150	304,363.78	3,774.40	35,590	39,364.40	343,728.18
Minnesota	90,000	68,128.03	90,783.35	39,790	288,701.38				288,701.38
Mississippi	90,000	80,016.75	114,584.58	43,655	328,256.33	2,269.81	27,000	29,269.81	357,526.14
Missouri	90,000	78,849.57	101,165.33	24,400	294,414.90		7,500	7,500.00	301,914.90
Montana	90,000	18,004.00	34,588.79	26,070	168,662.79				168,662.79
Nebraska	90,000	41,343.56	56,827.93	18,100	206,271.49				206,271.49
Nevada	90,000	3,435.49	21,930.44	8,400	123,765.93				123,765.93
New Hampshire	90,000	11,363.43	27,685.65	9,500	138,549.08				138,549.08

New Jersey	90,000	32,575.43	41,113.40	25,050	188,738.83	6,259.81	1,000	7,259.81	195,998.64
New Mexico	90,000	17,027.28	34,608.70	21,800	163,435.98				163,435.98
New York:									
Cornell	81,000	97,003.93	90,882.92	42,650	311,536.85	1,066.70	8,500	9,566.70	321,103.55
State	9,000	10,778.21	10,098.09		29,876.30	24.47	5,000	5,024.47	34,900.77
North Carolina	90,000	135,186.64	155,600.81	34,900	415,687.45	391.47		391.47	416,078.92
North Dakota	90,000	26,670.28	43,717.63	2,650	163,037.91				163,037.91
Ohio	90,000	118,853.05	120,920.85	20,100	349,873.90		13,160.00	13,160.00	363,033.90
Oklahoma	90,000	63,847.68	74,538.19	13,950	242,335.87				242,335.87
Oregon	90,000	35,230.21	48,229.16	27,900	201,359.37		7,000	7,000.00	208,359.37
Pennsylvania	90,000	155,317.78	129,669.28	29,300	404,287.06				404,287.06
Puerto Rico	90,000	66,036.41	106,959.51	3,500	266,495.92	4,927.00	2,210	7,137.00	273,632.92
Rhode Island	90,000	6,257.12	23,152.50	24,700	144,109.62				144,109.62
South Carolina	90,000	68,111.24	88,128.77	21,505	267,745.01				267,745.01
South Dakota	90,000	26,510.78	43,240.61	11,400	171,151.39				171,151.39
Tennessee	90,000	92,293.90	116,613.40	27,990	326,897.30	147.50	8,860	9,007.50	335,904.80
Texas	90,000	150,461.58	155,684.35	64,290	460,435.93	4,471.13	9,560	14,031.13	474,467.06
Utah	90,000	12,499.09	29,967.64	35,740	168,206.73				168,206.73
Vermont	90,000	12,884.06	29,549.88	11,200	143,633.94		2,500	2,500.00	146,133.94
Virginia	90,000	88,612.55	99,573.28	20,050	298,235.83				298,235.83
Washington	90,000	43,950.86	54,859.98	41,840	230,650.84	9.59	9,000	9,009.59	239,660.43
West Virginia	90,000	65,794.28	72,053.79	26,300	254,148.07		2,500	2,500.00	256,648.07
Wisconsin	90,000	73,259.15	92,166.74	42,420	297,845.89	6,446.73	12,500	18,946.73	316,792.62
Wyoming	90,000	7,662.93	26,032.07	17,150	140,845.00				140,845.00
Total	4,577,500	2,863,708.00	3,599,999.84	1,244,100	12,285,307.84	46,821.31	255,200	302,021.31	12,587,329.15

[1] Includes unexpended balances from the previous year as follows:
Hatch—Storrs (Connecticut), $457.41; Delaware, $0.07; Cornell (New York), $6.42; New York (State), $0.60; West Virginia, $2.55.
Adams—New York (State), $4.36; Rhode Island, $9.18; Washington, $0.77.
Purnell—Connecticut, $95.50; Storrs (Connecticut), $0.04; Cornell (New York), $104.47; New York (State), $0.86; Puerto Rico, $463.25.
Bankhead-Jones, title I:
Sec. 5—Connecticut, $0.36; Storrs (Connecticut), $9.34; Florida, $381.81; Minnesota, $0.82; Cornell (New York), $0.83; New York (State), $0.15; West Virginia, $2.
Secs. 9 (b) 1–2—Connecticut, $605.87; Storrs (Connecticut), $304.32; Delaware, $2.70; Florida, $61.61; Hawaii, $152; Indiana, $2,532.56; Cornell (New York), $351.44; Oregon, $4.05; Puerto Rico, $512.99; Wisconsin, $16,913.32.

[2] Hatch, $15,000 for each State, Alaska, Hawaii, and Puerto Rico. Adams, $15,000 for each State, Alaska, Hawaii, and Puerto Rico. Purnell, $60,000 for each State, Hawaii, and Puerto Rico; $42,500 for Alaska.

TABLE 4.—*Non-Federal funds available to the experiment stations for the year ended June 30, 1953*

Station	State appropriations	Special endowments, industrial fellowships, etc.	Fees	Sales	Miscellaneous	Balance from previous year	Total
Alabama	$687,000.00	$94,462.21		$548,449.21		$363,781.02	$1,693,692.44
Alaska	136,050.00			46,276.26		77,140.17	259,466.43
Arizona	366,280.76	25,411.22		43,544.86			435,236.84
Arkansas	367,250.00	29,664.75		234,051.45		133,296.43	764,262.63
California	5,570,227.97	287,307.25		76,680.20		419,152.45	6,353,367.87
Colorado	394,685.16	208,244.45		107,550.22	$7,400.00	181,005.54	898,885.37
Connecticut:							
State	378,701.17	21,345.00					400,046.17
Storrs	372,797.00	112,325.00	$11,749.00			47,281.00	544,152.00
Delaware	141,421.46			115,267.39	73,354.52	52,278.45	382,321.82
Florida	2,306,795.81	231,513.22		551,569.03		167,281.98	3,257,160.04
Georgia	226,900.00	21,608.40		160,071.63	11,080.51	218,163.15	637,823.69
Hawaii	408,081.11			82,136.39	14,205.57	8,884.34	513,307.41
Idaho	366,216.72	15,781.95		100,344.76		178,574.32	660,917.75
Illinois	1,630,391.57	291,223.05		318,297.63			2,239,912.25
Indiana	1,032,730.52	180,710.35	232,617.73	650,199.86	18,610.52	780,286.61	2,895,155.59
Iowa	1,080,000.00	657,368.98		624,390.96		317,490.27	2,679,250.21
Kansas	779,570.00	115,990.84		327,579.51		333,972.25	1,557,112.60
Kentucky	318,863.15	47,933.57	8,766.63	275,531.28	86,029.30	26,076.83	763,200.76
Louisiana	1,417,653.84	42,219.81			74,002.96		1,533,876.61
Maine	229,229.05	18,439.95		36,000.00		44,045.93	327,714.93
Maryland	415,155.56	113,995.93		140,848.43		98,386.46	768,386.38
Massachusetts	458,050.36	31,840.85				27,552.05	517,443.26
Michigan	1,193,812.64	290,637.09				78,158.15	1,562,607.88
Minnesota	1,485,588.05	205,071.33	9,345.30	471,833.18			2,171,837.86
Mississippi	797,442.93	69,953.68		565,786.34	7,635.54	237,458.90	1,678,277.39
Missouri	279,558.39	74,202.00	290,339.66	220,404.60		367,652.31	1,232,156.96
Montana	461,440.88	9,452.50		415,262.19		225,374.91	1,111,530.48
Nebraska	541,570.18			619,037.10		83,773.97	1,244,381.25
Nevada	34,628.57			42,146.39		43,649.72	120,424.68
New Hampshire	84,663.87	24,812.54		9,218.28		1,743.18	120,437.87
New Jersey	1,011,985.52	467,719.72				7,769.25	1,487,474.49
New Mexico	290,950.08	4,446.36		56,317.98	2,993.90	157,269.90	511,978.22
New York:							
Cornell	2,619,484.54	237,427.26		434,510.99	8,961.14		3,300,383.93
State	940,271.98			25,437.97			965,709.95
North Carolina	1,287,269.68	34,501.20			276,491.32		1,598,262.20

North Dakota	542,622.68	16,805.50		160,335.80		119,644.36	839,408.34
Ohio	1,023,296.32	225,553.17		345,737.27		353,686.88	1,948,273.64
Oklahoma	715,465.00	28,060.52		335,768.66	8,979.19	162,944.20	1,251,217.57
Oregon	1,314,571.55	153,067.38	245,981.28	222,806.92			1,936,427.13
Pennsylvania	764,514.87	174,733.36		160,123.13	95,914.09	92,546.11	1,287,831.56
Puerto Rico	745,962.05	11,000.00			143,183.00	116,905.62	1,017,050.67
Rhode Island	70,026.00	27,915.56		27,156.95		28,033.46	153,131.97
South Carolina	498,466.79	36,039.58		194,000.00		40,970.91	769,477.28
South Dakota	268,073.00	9,074.88		161,082.85		62,573.02	500,803.75
Tennessee	324,619.99	130,826.48		223,561.06			679,007.53
Texas	1,145,136.50	220,697.72	122,066.25	969,568.95	118,200.94	870,465.46	3,446,135.82
Utah	352,986.16	84,722.71		63,944.62	12,469.36	151,148.52	665,271.37
Vermont	75,483.08			2,923.23	15,138.48	19,865.74	113,410.53
Virginia	875,550.60			132,270.91			1,007,821.51
Washington	1,510,328.59	189,405.06		362,480.66			2,062,214.31
West Virginia	200,080.00	11,300.00		223,664.60	370.00	80,589.23	516,003.83
Wisconsin	1,430,533.00	797,940.00		595,357.00			2,823,830.00
Wyoming	331,107.48	10,769.72		103,191.19		76,285,11	521,353.50
Total	42,301,542.18	6,093,522.10	920,865.85	11,582,717.89	975,020.34	6,853,158.16	68,726,826.52

TABLE 5.—*Expenditures and appropriations under the Hatch Act (Mar. 2, 1887)[1] for the year ended June 30, 1953*

Station	Expenditures													Unexpended	Appropriation
	Personal Services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and reproduction	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Taxes and assessments	Total expenditures		
Alabama	$13,946.14	$188.77	$13.41	$18.28			$16.74	$732.96	$83.70				$15,000.00		$15,000
Alaska	14,005.97	231.80	9.01				90.85	662.37					15,000.00		15,000
Arizona	13,697.91	827.15		.82		$60.62		1.50	412.00				15,000.00		15,000
Arkansas	11,126.67	296.60			$70.00	1,601.03	126.68	1,516.93	88.75		$173.34		15,000.00		15,000
California	15,000.00												15,000.00		15,000
Colorado	9,848.59	1,107.34	39.80	31.39	245.22	179.55	177.37	1,606.79	1,310.25		453.70		15,000.00		15,000
Connecticut:															
State	1,500.00					3,082.37	300.00	1,162.21	1,414.50				7,459.08	$40.92	7,500
Storrs	4,945.50	460.04				83.16		233.42	1,738.53				7,460.65	39.35	7,500
Delaware	11,208.69	418.49		459.20		186.20	48.30	2,315.91	363.21				15,000.00		15,000
Florida	15,000.00												15,000.00		15,000
Georgia	9,872.55					1,164.62	57.40	2,175.35	1,730.08				15,000.00		15,000
Hawaii	14,475.66	27.87						164.27	332.20				15,000.00		15,000
Idaho	10,333.70	2,105.99	32.77	21.61	7.50	2,256.16	80.03	162.24					15,000.00		15,000
Illinois	13,434.78					942.06					623.16		15,000.00		15,000
Indiana	15,000.00												15,000.00		15,000
Iowa	8,172.41		66.88			4,229.46		2,531.25					15,000.00		15,000
Kansas	13,467.96	671.24		163.50	86.36	32.66	97.25	370.42				$110.61	15,000.00		15,000
Kentucky	13,825.00	123.54				690.00		190.84	69.14			101.48	15,000.00		15,000
Louisiana	12,902.15	22.08	2.76				997.80	34.93	1,040.28				15,000.00		15,000
Maine	14,338.57	69.34		.75	128.34	65.53		209.64	187.83				15,000.00		15,000
Maryland	6,500.00	4,282.94				1,088.61		247.60	2,880.85				15,000.00		15,000
Massachusetts	8,970.00	404.09	7.12			258.25	553.60	803.30	4,003.64				15,000.00		15,000
Michigan	7,500.00					7,500.00							15,000.00		15,000
Minnesota	11,993.92	469.89				395.93		666.31	1,240.27		233.68		15,000.00		15,000
Mississippi	14,169.12		29.32	44.22	170.72		57.41	453.31	75.90				15,000.00		15,000
Missouri	10,472.23	854.08	36.67	22.62	12.50		1,257.58	1,751.49	367.16	$225.67			15,000.00		15,000
Montana	13,178.65	406.40	17.56	43.35		456.55	52.26	293.77	551.46				15,000.00		15,000
Nebraska	15,000.00												15,000.00		15,000
Nevada	10,194.75	538.25		471.35	88.04		31.00	3,198.61	478.00				15,000.00		15,000
New Hampshire	14,202.11	1.60	2.47	245.43				286.39	262.00				15,000.00		15,000

New Jersey	12,982.75	42.89	1.62	100.00			30.00	673.93	1,168.81				15,000.00		15,000
New Mexico	13,940.70		.94	26.95	372.28		245.74	284.60	7.00	121.79			15,000.00		15,000
New York:															
Cornell	9,865.98	79.40	20.15				104.02	2,837.40	578.50				13,485.45	14.55	13,500
State	953.72								546.00				1,499.72	.28	1,500
North Carolina	11,597.21	197.67			60.00	2,210.00	177.81	695.30	62.01				15,000.00		15,000
North Dakota	14,343.25										656.75		15,000.00		15,000
Ohio	13,237.04	880.57				206.25		101.14	575.00				15,000.00		15,000
Oklahoma	12,487.54	173.59					496.22	1,842.65					15,000.00		15,000
Oregon	12,595.50	2,034.57					261.00	3.42	105.51				15,000.00		15,000
Pennsylvania	6,395.74	1,068.48	6.27			4,336.58		710.21	2,482.72				15,000.00		15,000
Puerto Rico	14,140.51	367.21	18.00	24.00			41.00	345.28	64.00				15,000.00		15,000
Rhode Island	11,618.68	763.62		508.97		848.28	357.94	902.51					15,000.00		15,000
South Carolina	13,935.08			126.66			258.21	250.30	429.75				15,000.00		15,000
South Dakota	8,841.10	578.70	18.32	84.10		3,577.46	59.67	484.04	1,356.61				15,000.00		15,000
Tennessee	14,146.65			4.60		848.75							15,000.00		15,000
Texas	10,526.21	2,896.48		144.24		141.82	135.78	635.82	519.65				15,000.00		15,000
Utah	15,000.00												15,000.00		15,000
Vermont	11,744.12	123.57	.15	130.22		1,243.01	287.70	271.58	1,188.81			10.84	15,000.00		15,000
Virginia	14,997.00							3.00					15,000.00		15,000
Washington	13,612.79	254.95	96.78	2.25		89.03	211.84	719.91	12.45				15,000.00		15,000
West Virginia	9,528.79	164.33			819.25	2,714.01		673.27	1,100.35				15,000.00		15,000
Wisconsin	6,536.54	591.81	36.12		118.12		367.49	4,926.79	2,423.13				15,000.00		15,000
Wyoming	13,325.00		4.79	111.34		1,546.37	12.50						15,000.00		15,000
Total	614,634.93	23,725.34	460.91	2,785.85	2,178.33	42,034.32	6,991.19	38,132.96	31,250.05	347.46	2,140.63	222.93	764,904.90	95.10	765,000

[1] Extended to Hawaii by act of May 16, 1928; to Alaska by act of Feb. 23, 1929; and to Puerto Rico by act of Mar. 4, 1931.

TABLE 6.—*Expenditures and appropriations under the Adams Act (Mar. 16, 1906)[1] for the year ended June 30, 1953*

Station	Expenditures												Unexpended	Appropriation
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Taxes and assessments	Total expenditures		
Alabama	$12,001.75	$619.20	$4.29	$38.10	$430.05	$8.75	$1,372.11	$525.75				$15,000.00		$15,000
Alaska	14,163.26	535.85	13.22				272.67	15.00				15,000.00		15,000
Arizona	12,310.70	1,475.24	133.54	44.64	45.36	247.13	472.39	271.00				15,000.00		15,000
Arkansas	13,308.21	207.39	5.61		137.50	58.66	712.16	179.26		$391.21		15,000.00		15,000
California	15,000.00											15,000.00		15,000
Colorado	12,002.57	247.05	49.65	19.30	45.90	236.62	884.63	1,109.59		404.69		15,000.00		15,000
Connecticut:														
State	7,500.00											7,500.00		7,500
Storrs	7,500.00											7,500.00		7,500
Delaware	11,027.75	329.40	10.49			128.98	984.29	2,519.09				15,000.00		15,000
Florida	15,000.00											15,000.00		15,000
Georgia	13,736.43	76.16				19.59	1,067.82	100.00				15,000.00		15,000
Hawaii	13,341.10					627.73	153.00	878.17				15,000.00		15,000
Idaho	14,554.89	270.12			2.84	8.42	133.45	30.28				15,000.00		15,000
Illinois	14,283.51	27.19	36.18				32.50			620.62		15,000.00		15,000
Indiana	12,331.57		2.30			113.12	2,431.18					14,878.17	$121.83	15,000
Iowa	15,000.00											15,000.00		15,000
Kansas	12,142.29		9.62			17.38	2,700.71			130.00		15,000.00		15,000
Kentucky	14,517.75						312.03				$170.22	15,000.00		15,000
Louisiana	12,967.43	347.94	3.12	2.30		123.27	1,555.94					15,000.00		15,000
Maine	14,649.17		7.00	5.30		51.18	211.40	75.95				15,000.00		15,000
Maryland	11,933.30		1.75			28.80	2,394.93	626.22				14,985.00	15.00	15,000
Massachusetts	15,000.00											15,000.00		15,000
Michigan	15,000.00											15,000.00		15,000
Minnesota	14,014.84						246.81	406.00		332.35		15,000.00		15,000
Mississippi	11,306.34	185.25	11.91	79.80	724.80	326.37	1,967.62	397.91				15,000.00		15,000
Missouri	10,886.80	3.50	218.93	4.20	14.46	206.54	3,646.22	19.35				15,000.00		15,000
Montana	13,584.43	343.20	6.55	4.72		27.10	763.25	270.75				15,000.00		15,000
Nebraska	15,000.00											15,000.00		15,000
Nevada	12,515.28	401.29	4.98	53.22		12.05	1,386.18	627.00				15,000.00		15,000
New Hampshire	13,890.12	70.78	8.15	6.65			606.30	418.00				15,000.00		15,000

New Jersey	13,224.10	148.24		18.01		41.31	1,285.01	283.33				15,000.00		15,000
New Mexico	13,286.13		48.32	6.95	25.17	103.72	1,375.86	153.85				15,000.00		15,000
New York:														
Cornell	10,473.12	81.97				97.51	1,461.14	1,380.88				13,494.62	5.38	13,500
State	52.00							1,448.00				1,500.00		1,500
North Carolina	14,400.30						399.51	200.19				15,000.00		15,000
North Dakota	14,316.89					9.35	110.90	41.86		521.00		15,000.00		15,000
Ohio	14,118.42	12.60					604.98	264.00				15,000.00		15,000
Oklahoma	10,857.48	683.01		10.00		1,078.72	1,258.76	1,112.03				15,000.00		15,000
Oregon	15,000.00											15,000.00		15,000
Pennsylvania	14,531.27						317.69	151.04				15,000.00		15,000
Puerto Rico	11,802.48	245.30				421.73	1,489.98	284.90				14,244.39	755.61	15,000
Rhode Island	14,603.46		2.21		10.00	69.60	178.14	126.91				14,990.32	9.68	15,000
South Carolina	14,034.13	250.01		69.06	18.71	142.47	279.10	206.52				15,000.00		15,000
South Dakota	12,891.16	222.37	12.08			1.49	563.06	1,309.84				15,000.00		15,000
Tennessee	14,832.30		8.00	.31			159.39					15,000.00		15,000
Texas	13,361.39		6.20	21.82	78.65	1,071.64	38.76	17.44	$404.10			15,000.00		15,000
Utah	15,000.00											15,000.00		15,000
Vermont	12,636.70	316.59	25.76	.25	23.75	377.58	1,069.70	537.95			11.72	15,000.00		15,000
Virginia	14,941.35	58.65										15,000.00		15,000
Washington	14,188.02	22.58	19.19			1.75	726.71	41.75				15,000.00		15,000
West Virginia	12,890.08	90.37					1,192.50	827.05				15,000.00		15,000
Wisconsin	11,140.69		8.97			44.80	3,805.54					15,000.00		15,000
Wyoming	14,900.15			29.45			70.40					15,000.00		15,000
Total	687,951.11	7,271.25	658.02	414.08	1,557.19	5,703.36	40,694.72	16,856.86	404.10	2,399.87	181.94	764,092.50	907.50	765,000

[1] Extended to Hawaii by act of May 16, 1928, to Puerto Rico by act of Mar. 4 ,1931, and to Alaska by act of June 30, 1936.

TABLE 7.—*Expenditures and appropriations under the Purnell Act (Feb. 24, 1925)[1] for the year ended June 30, 1953*

Station	Expenditures													Unexpended	Appropriation
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and reproduction	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Taxes and assessments	Total expenditures		
Alabama	$48,319.78	$1,478.02	$24.51	$294.40	$1,088.06	$1,828.09	$397.81	$4,194.07	$2,375.26				$60,000.00		$60,000
Alaska	42,628.60	552.92						654.29	21.39	$3,642.80			47,500.00		47,500
Arizona	40,524.02	2,790.56	267.27	211.59	17.50	1,777.16	1,675.47	8,941.92	2,244.49	1,550.02			60,000.00		60,000
Arkansas	52,491.54	911.85	37.54		463.10	793.64	596.29	2,788.70	623.99		$1,293.35		60,000.00		60,000
California	60,000.00												60,000.00		60,000
Colorado	45,252.71	3,056.57	94.40	142.00	83.49	65.26	954.14	6,559.69	1,936.70		1,855.04		60,000.00		60,000
Connecticut:															
State	23,175.00	26.45				22.12	1,236.98	1,993.13	2,388.14	1,072.42			29,914.24	$85.76	30,000
Storrs	26,272.26	1,092.97				82.40	48.58	1,146.07	946.82				29,589.09	410.91	30,000
Delaware	50,919.31	1,726.91	55.23	11.35	27.00	569.49	687.42	3,905.01	2,098.28				60,000.00		60,000
Florida	60,000.00												60,000.00		60,000
Georgia	53,863.06	605.87	16.76			56.95	914.87	3,618.54	923.95				60,000.00		60,000
Hawaii	53,881.38		117.53				218.85	764.58	2,517.66	2,500.00			60,000.00		60,000
Idaho	47,967.36	1,799.78	.50				1.00	10,187.56	43.80				60,000.00		60,000
Illinois	53,558.99	2,047.59	.33			45.12	849.44	1,415.91	52.00		2,030.62		60,000.00		60,000
Indiana	56,766.81	647.74		49.85			44.58	2,468.47	22.55				60,000.00		60,000
Iowa	60,000.00												60,000.00		60,000
Kansas	55,613.38	306.51		30.24	9.78	6.40	1,021.22	2,436.76	24.90		550.81		60,000.00		60,000
Kentucky	46,730.96	2,050.13	4.75	180.89		4,061.00	245.43	5,407.95	790.60			$528.29	60,000.00		60,000
Louisiana	50,191.80	1,487.45	98.70	19.75	231.26	1,087.28	2,048.58	3,674.92	1,160.26				60,000.00		60,000
Maine	52,353.00	968.71	28.03	62.76	47.50		294.02	5,119.20	1,126.78				60,000.00		60,000
Maryland	49,282.34	636.07	6.59	90.53	18.64	176.97	1,062.79	7,177.47	1,548.60				60,000.00		60,000
Massachusetts	51,225.58	1,381.20	196.76		36.75		87.67	4,433.21	2,638.83				60,000.00		60,000
Michigan	60,000.00												60,000.00		60,000
Minnesota	55,268.99	573.33	31.04	241.06		119.28	464.85	2,003.30	638.00		660.15		60,000.00		60,000
Mississippi	50,290.34	593.45	149.68	176.68	962.17	698.97	941.50	4,267.03	1,920.18				60,000.00		60,000
Missouri	44,962.01	831.17	77.19	96.60	63.89	16.26	1,157.72	10,079.68	614.81	2,100.67			60,000.00		60,000
Montana	53,238.03	700.37	14.86	94.99	74.16	1,648.37	630.60	1,785.22	1,785.12	28.28			60,000.00		60,000
Nebraska	59,138.01						8.40	258.45	595.14				60,000.00		60,000
Nevada	41,178.89	626.62	71.62	263.55	744.12	980.68	189.61	13,100.13	2,844.78				60,000.00		60,000
New Hampshire	55,793.80	737.33	30.11	24.78	75.00	5.50	148.79	2,681.51	503.18				60,000.00		60,000

New Jersey	52,210.05	1,267.59	2.35	15.00	13.00	70.25	429.77	4,554.04	1,437.95				60,000.00		60,000
New Mexico	43,098.55	2,952.90	30.77	106.64	2,159.03		2,703.56	3,637.01	5,189.74	121.80			60,000.00		60,000
New York:															
Cornell	45,655.46	1,662.51	17.14	31.17	595.52	19.80	2,144.66	2,329.97	1,407.89				53,864.12	135.88	54,000
State	4,571.95		13.52				132.25	361.01	908.94				5,987.67	12.33	6,000
North Carolina	49,820.71	1,703.49	10.00	207.47		67.08	259.45	5,422.55	2,509.25				60,000.00		60,000
North Dakota	56,176.35	727.77		12.06	184.63	17.15	213.29	262.64	170.96		2,235.15		60,000.00		60,000
Ohio	55,858.22	1,822.62	1.56	6.91	2.39	9.37	310.27	1,469.49	519.17				60,000.00		60,000
Oklahoma	43,660.00	574.33	80.00		14.70		2,007.15	10,756.34	2,907.48				60,000.00		60,000
Oregon	57,824.66	540.75	6.76	72.26			24.35	832.13	699.09				60,000.00		60,000
Pennsylvania	55,826.59	533.64	23.08			1,066.61	161.48	1,692.70	695.90				60,000.00		60,000
Puerto Rico	47,327.49	3,229.84	104.08	3.00		217.71	591.27	4,099.33	4,053.60				59,626.32	373.68	60,000
Rhode Island	51,676.34	267.52	10.47		10.30	65.94	396.10	7,553.33	20.00				60,000.00		60,000
South Carolina	58,653.19	255.36	8.44	106.24	137.78	347.25	47.10	444.64					60,000.00		60,000
South Dakota	45,814.46	1,393.28	76.04	33.38	360.00	1,126.87	387.97	7,910.60	2,897.40				60,000.00		60,000
Tennessee	59,056.99	12.38	2.30	14.22	43.01	74.14		475.22	321.74				60,000.00		60,000
Texas	47,221.44	1,186.70	15.36	141.07	139.64	487.10	3,964.41	2,686.90	3,323.48	833.90			60,000.00		60,000
Utah	58,644.19	616.81					119.98	419.02	200.00				60,000.00		60,000
Vermont	47,153.55	3,246.29	49.32	5.51	234.46	1,507.63	802.39	3,729.52	2,651.41	508.00		111.92	60,000.00		60,000
Virginia	58,267.18	500.46	3.12				687.60	534.64	7.00				60,000.00		60,000
Washington	50,683.66	1,687.30	93.41	12.27			376.53	3,732.15	3,414.68				60,000.00		60,000
West Virginia	50,171.61	1,216.76			14.88		330.54	5,721.08	2,545.13				60,000.00		60,000
Wisconsin	58,144.70	167.00		18.49				907.91	761.90				60,000.00		60,000
Wyoming	56,693.86					3,137.50		17.17	151.47				60,000.00		60,000
Total	2,655,099.15	53,194.87	1,870.62	2,777.21	7,851.76	22,255.34	32,016.72	180,612.16	69,180.39	12,357.89	8,625.12	640.21	3,046,481.44	1,018.56	3,047,500

[1] Extended to Hawaii by act of May 16, 1928; to Alaska by act of Feb. 23, 1929; and to Puerto Rico by act of Mar. 4, 1931.

TABLE 8.—*Expenditures and appropriations under the Bankhead-Jones Act, title I, sec. 5, for the year ended June 30, 1953*

Station	Expenditures													Unexpended	Appropriation
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and reproduction	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Taxes and assessments	Total expenditures		
Alabama	$69,780.51	$2,608.49	$61.33	$71.35	$755.08	$209.68	$185.23	$12,671.43	$1,734.79	$228.00			$88,305.89		$88,305.89
Alaska	4,186.49	85.32					65.39	303.68	95.52				4,736.40		4,736.40
Arizona	13,177.30	1,524.01	5.46	327.00	18.00	24.95	297.94	1,020.59	345.43				16,740.68		16,740.68
Arkansas	55,834.70	2,194.87	3.78		397.80	2,021.18	214.77	2,440.41	1,709.46		$1,370.23		66,187.20		66,187.20
California	102,716.44												102,716.44		102,716.44
Colorado	20,002.25	910.37	4.36	61.15	252.91	39.15	229.59	2,385.68	811.21		763.49		25,460.16		25,460.16
Connecticut:															
State	7,857.36	215.60				71.85	97.50		1,247.85	1,676.21			11,166.37	$90.82	11,257.19
Storrs	7,978.75		2.41				60.00	3,137.06					11,178.22	78.97	11,257.19
Delaware	4,049.71	203.91					68.05	809.58	838.77				5,970.02		5,970.02
Florida	43,856.88	309.00	14.09		19.90		59.14	3,152.75	635.00				48,046.76		48,046.76
Georgia	85,064.43	1,118.93	18.98	23.20	356.13		896.02	8,619.58	2,028.22	277.46			98,402.95		98,402.95
Hawaii	7,755.82						315.00	155.62	736.73	1,500.00			10,463.17		10,463.17
Idaho	14,955.99	581.16		13.03				1,280.43	35.58				16,866.19		16,866.19
Illinois	92,768.68	859.52	19.51	.67		15.65	165.33	737.96	557.82		4,353.81		99,478.95		99,478.95
Indiana	68,637.17	329.53	49.53	6.40			126.00	8,511.01	1,089.83				78,749.47	391.85	79,141.32
Iowa	72,204.87							2,022.33					74,227.20		74,227.20
Kansas	44,236.42	228.00			193.15	99.77	299.09	7,215.08	237.69			$548.03	53,057.23		53,057.23
Kentucky	82,750.53	1,279.44	31.63	25.68		1,228.55	3,203.53	2,947.95	1,075.01			836.56	93,378.88		93,378.88
Louisiana	47,631.33	1,654.53	170.46	111.28	63.56	820.48	1,526.00	7,765.47	1,062.35	8.32			60,813.78		60,813.78
Maine	20,758.82	679.00	8.77	6.70	22.20		25.21	743.63	26.35				22,270.68		22,270.68
Maryland	25,391.60	61.55	26.96	38.65	34.49		571.21	8,175.78	1,099.14	1,089.24			36,488.62		36,488.62
Massachusetts	30,632.68	376.42	35.61				93.30	3,111.32	2,448.86				36,698.19		36,698.19
Michigan	93,777.64												93,777.64		93,777.64
Minnesota	51,779.63	2,602.76	541.86	64.74	113.47	155.87	962.08	7,289.51	4,093.44		524.67		68,128.03		68,128.03
Mississippi	68,638.67	1,584.55	169.43	338.04	1,178.72	116.30	787.05	5,055.86	2,148.13				80,016.75		80,016.75
Missouri	50,143.45	840.59	192.23	189.68	651.30	64.09	2,891.69	21,607.49	2,269.05				78,849.57		78,849.57
Montana	17,612.58		7.58				253.80	86.33		43.71			18,004.00		18,004.00
Nebraska	40,047.69					11.41		511.79	772.67				41,343.56		41,343.56
Nevada	2,641.97	110.10	9.87			11.50	22.40	343.15	43.00	253.50			3,435.49		3,435.49
New Hampshire	10,183.75	58.12		3.23				210.14	908.19				11,363.43		11,363.43

New Jersey	24,268.02	622.05			192.00	1.50	371.58	3,941.02	3,179.26				32,575.43		32,575.43
New Mexico	14,130.50	49.00	14.53	3.00			581.07	2,061.43	187.75				17,027.28		17,027.28
New York:															
Cornell	69,711.21	2,084.34	8.79		293.25	89.40	2,804.79	16,938.70	5,072.67				97,003.15	.78	97,003.93
State	10,778.04												10,778.04		10,778.04
North Carolina	113,344.64	2,761.68	100.68	537.65	110.59	110.19	3,273.09	9,640.63	5,307.49				135,186.64		135,186.64
North Dakota	25,609.46	54.61		.40			2.35	192.26	7.77		803.43		26,670.28		26,670.28
Ohio	110,306.70	1,388.85	43.71			51.78	391.15	5,019.08	1,371.35	280.43			118,853.05		118,853.05
Oklahoma	44,109.82	2,802.64		5.30	407.05		1,120.55	13,235.38	2,166.94				63,847.68		63,847.68
Oregon	29,675.60	1,058.88		99.54	19.81		357.99	906.57	3,111.82				35,230.21		35,230.21
Pennsylvania	130,278.92	2,236.76	106.61	50.12		2,509.20	173.93	16,609.30	3,352.94				155,317.78		155,317.78
Puerto Rico	42,290.13	452.78	132.35			200.00	171.72	20,407.26	2,074.45				65,728.69	307.72	66,036.41
Rhode Island	5,735.70	80.88					20.00	202.74	217.80				6,257.12		6,257.12
South Carolina	60,907.19	390.49	177.78	129.55	767.99		425.66	3,929.11	1,383.47				68,111.24		68,111.24
South Dakota	21,479.65	133.42	3.07	1.45		520.16	2.00	4,371.03					26,510.78		26,510.78
Tennessee	84,168.71	664.79	27.94	18.46	80.79	15.48	995.95	4,694.16	1,627.62				92,293.90		92,293.90
Texas	116,535.95	2,948.23	83.43	469.82	329.68	802.64	10,375.10	10,490.10	7,682.52	744.11			150,461.58		150,461.58
Utah	12,388.14	37.75	3.73				18.00	14.85	36.62				12,499.09		12,499.09
Vermont	10,520.38	195.00	4.34	75.83	120.88	1.50	76.67	828.46	1,041.61			19.39	12,884.06		12,884.06
Virginia	86,423.06	93.13	7.42	3.99			39.50	1,264.28	781.17				88,612.55		88,612.55
Washington	39,039.36	366.76	134.19	38.85			280.65	2,573.33	1,517.72				43,950.86		43,950.86
West Virginia	53,032.91	1,233.10	6.30		51.24	3,525.73	108.16	5,036.35	2,800.49				65,794.28		65,794.28
Wisconsin	56,604.32	613.21	111.49		28.03		800.76	11,808.48	3,292.86				73,259.15		73,259.15
Wyoming	7,539.00	10.50						113.43					7,662.93		7,662.93
Total	2,425,931.52	40,694.62	2,340.21	2,714.76	6,458.02	12,718.01	35,805.99	246,589.56	74,264.41	6,100.98	7,815.63	1,403.98	2,862,837.69	870.14	2,863,707.83

TABLE 9.—*Expenditures and funds available under the Bankhead-Jones Act, title I, secs. 9 (b) 1 and 9 (b) 2, for the year ended June 30, 1953*

Station	Expenditures													Unexpended	Appropriation
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and reproduction	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Taxes and assessments	Total expenditures		
Alabama	$82,663.19	$7,023.85	$346.54	$492.30	$1,814.59	$1,501.69	$663.54	$10,841.63	$4,953.25	$650.00			$110,950.58		$110,950.58
Alaska	20,154.65	204.95			5.00		52.54	1,286.58	193.95				21,897.67		21,897.67
Arizona	21,327.29	2,846.52	180.62	182.50	12.00	616.19	1,227.99	2,262.11	2,900.07				31,555.29		31,555.29
Arkansas	75,487.03	1,804.67	7.42		1,845.20	360.78	830.88	6,667.80	3,944.68		$1,131.13		92,079.59		92,079.59
California	100,038.22												100,038.22		100,038.22
Colorado	32,976.25	1,642.63	4.55	51.15	203.06	16.68	409.39	3,848.07	1,252.53		1,300.26		41,704.57		41,704.57
Connecticut:															
State	11,545.49	131.96	59.94			1,713.92	340.00	2,189.07	851.21				16,831.59	$28.51	16,860.10
Storrs	12,742.54	503.91			20.37	25.00	6.00	467.17	3,090.86				16,855.85	4.24	16,860.09
Delaware	21,800.34	1,233.56	1.57	1.00	519.46		194.15	171.12	302.48				24,223.68		24,223.68
Florida	51,706.74	1,090.19			276.58		602.72	580.23	260.00				54,516.46		54,516.46
Georgia	98,025.79	1,494.01	92.27		568.22	8.99	2,660.75	8,986.75	2,986.16				114,822.94		114,822.94
Hawaii	22,606.72	2,313.75	142.78	42.00		471.00	160.52	1,128.07	2,239.33				29,104.17		29,104.17
Idaho	25,161.97	2,706.62	10.16	56.88	148.65		179.80	7,675.72	377.92				36,317.72		36,317.72
Illinois	84,106.07	1,988.53	81.51	30.30		176.49	3,644.49	8,171.67	4,377.06		3,502.54		106,078.66		106,078.66
Indiana	76,882.41	214.94	140.27	1.00	9.35		191.17	5,762.15	1,492.12				84,693.41	7,217.95	91,911.36
Iowa	93,449.77												93,449.77		93,449.77
Kansas	54,754.57	703.91	16.98	86.02	32.97	28.84	530.80	6,897.94	844.85		585.36		64,482.24		64,482.24
Kentucky	88,770.37	4,464.63	102.12	122.76	16.66	1,229.04	4,751.27	12,266.31	2,176.76			$898.53	114,798.45		114,798.45
Louisiana	63,608.91	2,429.09	31.18	83.80	270.61	325.45	2,620.84	6,898.69	1,235.90	642.31			78,146.78		78,146.78
Maine	32,321.71	1,961.76	26.21	54.34	34.10		249.17	1,622.90	646.56				36,916.75		36,916.75
Maryland	33,747.67	1,097.53	23.36	75.73	124.88	466.47	310.17	6,155.94	3,792.61				45,794.36	588.15	46,382.51
Massachusetts	27,160.34	2,170.95	37.68	10.00	7.92		585.41	8,265.13	3,301.06				41,538.49		41,538.49
Michigan	97,368.24	1,434.70	11.05	15.75	33.00	357.86	284.81	774.50	156.23				100,436.14		100,436.14
Minnesota	68,653.13	4,485.37	165.48	200.85	12.50	4,399.34	2,207.76	8,676.80	1,982.12				90,783.35		90,783.35
Mississippi	95,120.66	4,000.73	143.52	465.75	1,604.93	551.51	2,057.30	8,901.81	1,738.37				114,584.58		114,584.58
Missouri	76,769.45	1,507.91	177.69	280.41	1,190.97	44.84	2,606.73	15,971.84	740.49	1,875.00			101,165.33		101,165.33
Montana	30,859.01	1,078.19	60.51	40.24		101.21	767.04	1,064.58	618.01				34,588.79		34,588.79
Nebraska	55,170.81	656.94	17.51			74.00	370.28	363.39	175.00				56,827.93		56,827.93
Nevada	17,627.88	548.77	24.27	132.10	355.24		390.89	1,999.88	797.41	54.00			21,930.44		21,930.44
New Hampshire	25,230.37	122.62	14.37	12.75		74.45	24.08	1,823.88	383.13				27,685.65		27,685.65

New Jersey	31,976.93	831.01	120.16	3.85	84.00	147.78	1,660.95	3,487.27	2,801.45				41,113.40		41,113.40
New Mexico	27,535.68	1,073.34	651.36	28.46	538.38		945.04	3,133.30	703.14				34,608.70		34,608.70
New York:															
Cornell	51,832.81	13,027.16	105.84	209.47	619.08	623.83	4,528.40	12,764.05	6,823.91				90,534.55	348.37	90,882.92
State	4,707.88	39.00			3.75		1,251.83	1,730.58	2,347.75				10,080.79	17.30	10,098.09
North Carolina	130,052.43	1,906.95	91.54	141.51		138.34	1,520.14	9,014.38	9,720.83	3,000.00			155,586.12	14.69	155,600.81
North Dakota	39,489.85	669.60	7.75	77.98	470.97	300.00	86.71	1,087.47	205.10		1,322.20		43,717.63		43,717.63
Ohio	109,206.32	3,943.36	49.27	35.70		322.06	2,179.72	1,414.02	2,827.99	942.41			120,920.85		120,920.85
Oklahoma	59,481.08	978.52			336.84		2,357.17	9,721.21	1,663.37				74,538.19		74,538.19
Oregon	43,622.96	1,421.87	7.22	10.95			343.46	727.94	2,094.76				48,229.16		48,229.16
Pennsylvania	94,323.34	1,909.07	61.37	24.18		2,959.39	314.40	21,283.59	8,793.94				129,669.28		129,669.28
Puerto Rico	78,304.42	2,012.89	33.69	3.00		455.38	242.49	20,085.10	5,745.96				106,882.93	76.58	106,959.51
Rhode Island	20,806.86	112.31			541.04		12.43	1,123.07	470.18				23,065.89	86.61	23,152.50
South Carolina	78,601.15	1,860.69	110.22	405.51	500.80	951.85	937.99	4,140.58	619.98				88,128.77		88,128.77
South Dakota	31,986.88	677.34	21.22	10.73		859.02	18.86	8,274.85	1,391.71				43,240.61		43,240.61
Tennessee	98,632.67	2,560.76	101.53	107.33	24.94	12.83	1,509.77	8,409.72	5,253.85				116,613.40		116,613.40
Texas	112,864.33	5,444.35	203.60	919.15	343.11	1,851.79	14,172.54	12,393.50	6,536.98	955.00			155,684.35		155,684.35
Utah	17,395.94	431.55	107.39		92.72	42.00	663.16	9,802.56	1,383.72	48.60			29,967.64		29,967.64
Vermont	25,625.56	447.82	8.06		141.03	418.00	361.03	1,156.21	1,186.19	140.19		49.45	29,533.54	16.34	29,549.88
Virginia	88,367.38	2,514.32	5.81	170.60	196.00	3,065.29	1,552.65	2,348.76	1,352.47				99,573.28		99,573.28
Washington	38,907.28	1,806.34	255.99	38.49		33.20	1,722.79	8,173.67	3,922.22				54,859.98		54,859.98
West Virginia	57,288.53	3,914.93			72.00	253.74	350.12	4,783.19	5,391.28				72,053.79		72,053.79
Wisconsin	58,977.02	2,714.26	69.20	3.50			786.54	21,162.63	4,032.34				87,745.49	4,421.25	92,166.74
Wyoming	17,944.00	1,773.43	99.58	168.62		104.08	195.36	1,056.38	4,690.62				26,032.07		26,032.07
Total	2,915,768.89	103,934.06	4,030.36	4,796.66	13,070.92	25,082.33	66,634.04	308,995.76	127,769.86	8,307.51	7,841.49	947.98	3,587,179.86	12,819.99	3,599,999.85

TABLE 10.—*Expenditures and funds available under the Bankhead-Jones Act, title I, sec. 9 (b) 3, for the year ended June 30, 1953*

Station	Expenditures													Unexpended	Funds available
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and reproduction	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirements	Taxes and assessments	Total expenditures		
Alabama	$15,171.82	$1,533.28	$90.52	$23.44	$264.00		$100.00	$3,481.76	$145.18				$20,810.00		$20,810
Alaska															
Arizona	17,556.12	684.43	17.80	41.15		$1,121.00	1,376.93	2,326.75	3,625.82				26,750.00		26,750
Arkansas	18,146.17	455.46						119.94	488.12		$90.00		19,299.69	$0.31	19,300
California	29,110.56	2,957.89	73.80	4.06			2,719.15	1,039.06	3,645.48				39,550.00		39,550
Colorado	20,992.08	4,379.69	17.72	98.75	823.43	1,310.61	737.78	3,293.04	3,566.85		630.05		35,850.00		35,850
Connecticut:															
State	2,145.00								849.52				2,994.52	5.48	3,000
Storrs	12,079.10	1,089.47		.30		126.06		881.19	3,036.35				17,212.47	87.53	17,300
Delaware	2,500.00												2,500.00		2,500
Florida	7,795.50	4,226.97	20.59				237.75	373.56	245.63				12,900.00		12,900
Georgia	31,982.51	5,268.31	41.80	6.31	190.43		142.06	4,529.65	2,688.93				44,850.00		44,850
Hawaii	4,250.53	174.36	4.92	.92			458.50	89.67	21.10				5,000.00		5,000
Idaho	15,047.75	135.26		.63				2,369.49	146.87				17,700.00		17,700
Illinois	16,412.15	2,849.98	78.97	48.55	64.50	1,598.11	1,778.08	2,683.39	3,432.87		421.07		29,367.67	1,252.33	30,620
Indiana	19,722.03	2,663.73	277.36	16.80	509.55		733.41	16,767.73	4,140.08	$4,421.97			49,252.66	897.34	50,150
Iowa	28,778.44	6,391.35	62.83	226.41	614.25	122.59	3,828.65	18,013.95	1,649.87				59,688.34	81.66	59,770
Kansas	9,400.97	1,601.79	94.09	35.71		2,391.45	758.80	4,532.58	665.65			$45.88	19,526.92	23.08	19,550
Kentucky	5,258.67	742.79		53.74				663.66	125.00			56.14	6,900.00		6,900
Louisiana	13,005.63	1,498.47	17.16	39.00	456.68	26.57	451.10	2,135.45	2,419.94				20,050.00		20,050
Maine	18,140.61	3,033.40	94.29	103.84	152.15	295.47	25.37	882.01	172.86				22,900.00		22,900
Maryland	9,697.57	1,856.38	4.81	44.94	191.13	315.25	763.07	4,025.01	2,851.84				19,750.00		19,750
Massachusetts	7,066.25	945.86				874.60	3,000.00	124.37		400.52			12,411.60	38.40	12,450
Michigan	14,972.52	2,811.87	96.08				79.65	1,349.41	838.01				20,147.54	2.46	20,150
Minnesota	29,295.57	3,917.49	46.95	105.38	18.00	406.48	1,443.69	2,712.84	1,843.60				39,790.00		39,790
Mississippi	31,816.38	5,383.12	121.56	332.42	72.00	2,529.60	860.69	1,139.10	1,400.13				43,655.00		43,655
Missouri	19,604.20	1,505.17	20.77	28.93	37.66	60.30	863.16	2,055.64	224.17				24,400.00		24,400
Montana	15,701.55	4,177.42	81.93	135.17	25.00	63.25	2,660.52	2,000.60	1,224.44				26,069.88	.12	26,070
Nebraska	17,041.14	1,058.86											18,100.00		18,100
Nevada	7,153.81	574.90	4.05	23.00			3.25	548.99	42.00	50.00			8,400.00		8,400
New Hampshire	5,797.06	1,803.85	4.20	23.55		24.00	358.45	1,485.49	3.40				9,500.00		9,500

New Jersey	20,310.05	1,671.52		1.68	64.00	80.00	103.62	1,242.36	1,117.93				24,591.16	458.84	25,050
New Mexico	17,205.56	535.91	98.24	68.86			500.41	3,321.02	70.00				21,800.00		21,800
New York:															
Cornell	19,181.44	3,485.95	64.79	254.50	76.00	232.60	4,590.90	5,278.63	9,121.63				42,286.44	363.56	42,650
State															
North Carolina	27,068.11	3,865.08	9.91	75.67			603.38	987.60	2,290.25				34,900.00		34,900
North Dakota	2,218.47	42.04					135.00	140.49	89.75		24.25		2,650.00		2,650
Ohio	16,899.28	1,881.73						659.49	659.50				20,100.00		20,100
Oklahoma	9,635.76	1,919.49					283.51	1,432.62	678.62				13,950.00		13,950
Oregon	25,686.81	367.27	30.98	120.47			81.35	1,545.17	67.95				27,900.00		27,900
Pennsylvania	20,025.70	959.50	30.27	61.00			65.98	3,255.13	4,902.42				29,300.00		29,300
Puerto Rico	2,847.72							468.50					3,316.22	183.78	3,500
Rhode Island	21,837.79	525.15			196.43	963.64	88.01	376.85	712.13				24,700.00		24,700
South Carolina	20,402.05	61.50		73.30			57.61	910.54					21,505.00		21,505
South Dakota	7,985.64	321.01	4.15	12.58			25.49	2,746.13	305.00				11,400.00		11,400
Tennessee	25,559.39	969.52	347.19	18.34		240.00	184.95	434.45	236.16				27,990.00		27,990
Texas	45,421.45	7,222.77	4.94	382.02	505.38	135.13	1,566.36	5,171.05	3,609.42	271.48			64,290.00		64,290
Utah	20,961.21	2,554.07	88.49	6.00	2.85	141.80	720.00	9,895.63	1,369.95				35,740.00		35,740
Vermont	9,248.46	458.07	32.53				6.75	1,232.64	203.51			6.33	11,188.29	11.71	11,200
Virginia	10,026.61	508.26				1,278.71	7,986.00	142.85	107.57				20,050.00		20,050
Washington	30,148.77	3,354.46	53.56	32.54	10.00		2,560.04	4,291.79	1,256.84				41,708.00	132.00	41,840
West Virginia	19,208.13	2,058.87		1.50	1.80	569.43	229.98	2,604.56	1,623.11				26,297.38	2.62	26,300
Wisconsin	19,205.10	5,190.60	12.93	27.40	260.73	967.03	333.01	12,346.99	3,194.83	270.17			41,808.79	611.21	42,420
Wyoming	7,976.40	3,131.71	31.12	338.86			84.75	1,936.89	3,650.27				17,150.00		17,150
Total	844,701.59	104,806.03	2,081.30	2,867.72	4,535.97	15,873.68	43,587.16	140,045.71	74,760.55	5,414.14	1,165.37	108.35	1,239,947.57	4,152.43	1,244,100

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TABLE 11.—*Expenditures from non-Federal funds for the year ended June 30, 1953*

Station	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and reproduction	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Taxes and assessments	Total	Unexpended balances
Alabama	$738,518.18	$35,915.80	$6,592.18	$7,812.80	$22,060.10	$6,595.14	$61,418.84	$378,995.17	$127,539.37	$30,859.99	$3,808.35		$1,420,115.92	$273,576.52
Alaska	113,375.85	1,854.01	790.73	81.50	125.50	772.75	6,676.98	26,654.47	21,820.13	21,041.89		$1,826.99	195,020.80	64,445.63
Arizona	325,364.98	10,770.78	1,177.75	3,186.51	1,136.72	7,963.88	16,154.56	41,145.14	17,632.30	7,444.42		3,259.80	435,236.84	
Arkansas	352,926.15	19,670.24	2,135.48	3,581.67	15,908.75	5,966.18	41,692.16	146,496.49	32,443.14	3,993.84	4,049.26	4,629.93	633,493.29	130,769.34
California	4,616,776.80	226,023.18	9,564.39	67,095.58	66,807.85	84,367.61	165,337.72	360,900.27	270,034.55				5,866,907.95	486,459.92
Colorado	378,891.24	15,694.61	1,409.10	5,528.90	45,281.15	7,840.27	65,560.36	133,497.58	66,143.37	45.00	10,200.29		730,091.87	168,793.50
Connecticut:														
State	308,122.15	2,478.17	201.46	2,812.71	9,754.54	7,071.14	10,072.11	24,693.61	16,735.30				381,941.19	18,104.98
Storrs	320,680.42	5,613.09	204.74			4,639.06	7,620.08	50,725.54	48,671.07	43,000.00			481,154.00	62,998.00
Delaware	168,035.87	7,843.95	1,229.12	5,002.37	5,849.12	2,373.20	18,088.48	101,353.52	18,403.96				328,179.59	54,142.23
Florida	1,960,153.67	73,405.51	5,320.53	16,817.46	49,196.17	24,959.06	54,555.43	416,541.00	172,478.03	91,784.35			2,865,211.21	391,948.83
Georgia	221,109.21	9,338.26	1,760.01	3,042.08	13,180.91	376.96	10,082.87	125,120.83	21,332.74	74,051.61	802.07		480,197.55	157,626.14
Hawaii	374,283.82	4,686.22	1,250.28	2,628.64	8,533.96	5,687.63	26,389.34	60,653.85	21,344.66				505,458.40	7,849.01
Idaho	323,568.04	12,539.92	5,500.00	10,000.00	12,500.00	2,250.00	5,000.00	74,521.22	43,716.15	50,195.55		90.00	539,880.88	121,036.87
Illinois	1,562,252.70	100,000.00		30,000.00		75,000.00	50,000.00	373,447.95	49,211.60				2,239,912.25	
Indiana	1,182,540.76	45,624.01	10,003.77	15,930.38	23,678.02	105,378.47	112,657.06	625,094.04	117,400.95	77,555.40			2,315,862.86	679,292.73
Iowa	1,194,780.00	89,917.26	4,662.51	9,014.63	11,100.37	36,038.09		774,344.91	108,434.84	74,413.04	64,630.19		2,367,335.84	311,914.37
Kansas	831,102.15	19,304.91	16,062.25	6,819.56	18,854.68	17,468.09	38,817.26	210,071.04	163,680.71	18.00		1,631.56	1,323,830.21	233,282.39
Kentucky	517,619.00	22,586.14	3,535.69	5,654.25	15,244.92	23,336.73	32,322.49	108,511.04	28,089.27		6,301.23		763,200.76	
Louisiana	935,684.67	40,811.30	2,283.13	9,712.05	24,416.55	5,804.31	130,283.36	239,156.25	69,339.47	76,385.52			1,533,876.61	
Maine	173,509.01	15,640.62	1,982.83	2,685.49	8,627.97	7,556.80	12,247.54	43,182.52	22,916.25				288,349.03	39,365.90
Maryland	388,336.15	14,675.32	791.07	2,830.21	3,600.70	4,062.64	28,034.89	153,219.40	58,652.97	2,603.52			656,806.87	111,579.51
Massachusetts	441,565.37	7,841.68	757.85	4,985.33	497.18	3,978.17	4,863.49	25,491.20	3,809.51				493,789.78	23,653.48
Michigan	1,116,118.51	37,004.05	2,389.14	3,401.99	8,135.98	15,633.50	76,541.37	179,545.96	61,791.77				1,500,562.27	62,045.61
Minnesota	1,432,077.09	28,772.73	9,691.84	13,710.52	28,821.91	14,232.50	173,798.30	344,788.25	113,448.08	12,496.64			2,171,837.86	
Mississippi	674,538.84	14,987.63	6,401.80	6,474.49	39,873.32	13,127.54	56,419.02	341,392.69	92,124.43	28,379.24	16,176.75		1,289,895.75	388,381.64
Missouri	414,461.62	40,642.74	2,001.36	6,993.69	8,853.16	31,898.30	50,774.79	129,521.78	40,521.81	15,420.34	7,540.46		748,630.05	483,526.91
Montana	475,101.89	10,043.26	3,047.27	4,920.66	43,244.48	6,822.07	26,827.70	219,891.10	41,102.53	40,275.87	18,290.87		889,567.70	221,962.78
Nebraska	614,885.30	28,122.08	8,869.33	5,532.86	13,560.60	8,965.15	13,716.97	365,732.12	144,744.52	9,063.68			1,203,192.61	41,188.64
Nevada	31,475.76	2,213.51	138.44	730.13	2,791.19	296.76	5,446.77	18,981.40	9,085.20		802.56		71,961.72	48,462.96
New Hampshire	77,429.45	4,791.59	82.16	883.80	608.00	1,620.29	230.32	24,484.20	9,888.21				120,018.02	419.85
New Jersey	1,019,050.78	38,699.16	2,487.75	20,262.00	38,135.35	11,430.88	140,256.75	156,937.52	55,852.46		199.87		1,483,312.52	4,161.97
New Mexico	235,158.54	5,863.86	873.57	1,276.43	7,433.26	3,155.16	21,029.80	58,389.49	38,818.43	98,469.93	7,902.28		478,370.75	33,607.47
New York:														
Cornell	2,194,839.32	56,413.77	5,126.82	23,825.06	170,084.19	15,488.74	151,556.85	334,864.21	107,304.37	3,453.34			3,062,956.67	237,427.26
State	798,101.06	9,483.36	1,467.00	4,881.37	14,135.49	14,608.67	12,542.98	69,608.55	40,881.47				965,709.95	
North Carolina	1,153,416.89	31,595.54	2,790.28	13,048.31	16,895.96	15,440.40	89,163.77	161,909.03	96,673.23	17,328.79			1,598,262.20	

North Dakota	358,788.24	11,513.35	1,844.71	3,431.58	27,150.01	20,413.15	40,054.43	122,304.60	57,792.40	68,629.22	6,444.23		718,365.92	121,042.42
Ohio	997,344.09	25,449.10	7,186.31	9,180.04	24,765.86	6,883.13	27,190.97	312,954.35	50,582.97	163,336.06			1,624,872.88	323,400.76
Oklahoma	628,589.39	29,893.30	2,978.85	3,794.08	31,557.77	12,460.03	78,543.40	301,418.96	44,713.55	29,493.93		3,998.54	1,167,441.80	83,775.77
Oregon	1,248,837.17	69,713.05	7,342.39	11,758.92	19,492.66	21,969.80	46,248.92	292,152.65	129,781.01	30,511.00	53,017.65	5,601.91	1,936,427.13	
Pennsylvania	811,236.97	30,630.91	1,432.84	4,023.75	8,010.59	9,809.19	4,976.61	224,354.48	35,144.01	41,136.85			1,170,756.20	117,075.36
Puerto Rico	478,428.92	17,840.84	1,226.32	4,232.56	17,436.36	9,830.47	18,596.10	132,284.22	35,122.50	73,267.90	31,000.00	14,152.48	833,418.67	183,632.00
Rhode Island	101,677.39	2,095.72	112.05	655.99	1,082.62	829.64	1,420.21	12,149.67	3,103.74				123,127.03	30,004.94
South Carolina	499,130.77	14,384.39	359.14	2,642.96	4,382.67	3,102.91	21,593.97	134,761.07	43,699.81				724,057.69	45,419.59
South Dakota	250,317.26	13,930.23	635.98	2,089.23	1,152.90	6,220.12	320.76	111,223.49	66,077.84				451,967.81	48,835.94
Tennessee	836,994.35	16,614.05	6,240.23	6,629.23	9,841.85	6,784.23	33,484.63	145,860.18	58583.83	7,974.95			679,007.53	
Texas	1,490,890.35	41,299.61	3,893.37	19,260.16	47,567.02	2,759.00	372,285.65	378,486.94	293,818.01	61,959.38	18,209.00		2,730,428.49	715,707.33
Utah	347,827.13	22,142.03	2,736.86	3,355.44	10,327.06	14,228.76	14,253.17	111,815.24	55,783.36	20,632.38			603,101.43	62,169.94
Vermont	46,934.67	3,696.53	168.12	1,528.42	6,093.38	163.44	13,237.89	4,860.93	3,002.19	96.00	4,154.38	1,656.30	85,592.25	27,818.28
Virginia	584,050.69	28,009.80	4,311.04	9,734.12	24,362.39	3,054.89	33,070.59	143,607.17	66,333.43	55,455.35			951,989.47	55,832.04
Washington	1,290,890.78	65,377.43	13,125.53	12,695.18	25,282.78	19,365.54	69,393.17	398,069.33	108,745.92	4,060.26	55,208.39		2,062,214.31	
West Virginia	191,144.60	5,274.22	1,161.14	1,343.75	17,409.47	2,375.50	26,909.93	110,277.95	34,014.20				389,910.76	126,093.07
Wisconsin	2,106,832.00	31,205.00	3,506.00	2,691.00	12,590.00	12,756.00	59,206.00	513,764.00	81,280.00				2,823,830.00	
Wyoming	244,304.49	25,895.33	9,792.08		11,418.31	2,339.53	19,051.21	107,934.76	42,992.25	552.00			464,279.96	57,073.54
Total	39,730,070.50	1,545,833.15	190,634.59	420,209.84	1,048,851.75	747,551.47	2,586,018.02	10,458,143.33	3,562,637.87	1,335,385.24	308,737.83	36,847.51	61,970,921.10	6,755,905.42

TABLE 12.—*Summary, by States, of expenditures of the experiment stations for the year ended June 30, 1953*

Station	Federal-grant funds							Contractual Federal funds, Agricultural Marketing Act, title II	Non-Federal funds	Grand total
	Hatch	Adams	Purnell	Sec. 5	Secs. 9 (b) 1 and 9 (b) 2	Sec. 9 (b) 3	Total			
Alabama	$15,000.00	$15,000.00	$60,000.00	$88,305.89	$110,950.58	$20,810.00	$310,086.47		$1,420,115.92	$1,730,182.39
Alaska	15,000.00	15,000.00	47,500.00	4,736.40	21,897.67		104,134.07		195,020.80	299,154.87
Arizona	15,000.00	15,000.00	60,000.00	16,740.68	31,555.29	26,750.00	165,045.97		435,236.84	600,282.81
Arkansas	15,000.00	15,000.00	60,000.00	66,187.20	92,079.59	19,299.69	267,566.48		633,493.29	901,059.77
California	15,000.00	15,000.00	60,000.00	102,716.44	100,038.22	39,550.00	332,304.66	$11,700.00	5,866,907.95	6,210,912.61
Colorado	15,000.00	15,000.00	60,000.00	25,460.16	41,704.57	35,850.00	193,014.73		730,091.87	923,106.60
Connecticut:										
State	7,459.08	7,500.00	29,914.24	11,166.37	16,831.59	2,994.52	75,865.80		381,941.19	457,806.99
Storrs	7,460.65	7,500.00	29,589.09	11,178.22	16,855.85	17,212.47	89,796.28	5,121.76	481,154.00	576,072.04
Delaware	15,000.00	15,000.00	60,000.00	5,970.02	24,223.68	2,500.00	122,693.70		328,179.59	450,873.29
Florida	15,000.00	15,000.00	60,000.00	48,046.76	54,516.46	12,900.00	205,463.22	4,500.21	2,865,211.21	3,075,174.64
Georgia	15,000.00	15,000.00	60,000.00	98,402.95	114,822.94	44,850.00	348,075.89	16,452.10	480,197.55	844,725.54
Hawaii	15,000.00	15,000.00	60,000.00	10,463.17	29,104.17	5,000.00	134,567.34	6,410.50	505,458.40	646,436.24
Idaho	15,000.00	15,000.00	60,000.00	16,866.19	36,317.72	17,700.00	160,883.91		539,880.88	700,764.79
Illinois	15,000.00	15,000.00	60,000.00	99,478.95	106,078.66	29,367.67	324,925.28	4,009.31	2,239,912.25	2,568,846.84
Indiana	15,000.00	14,878.17	60,000.00	78,749.47	84,693.41	49,252.66	302,573.71	17,947.05	2,315,862.86	2,636,383.62
Iowa	15,000.00	15,000.00	60,000.00	74,227.20	93,449.77	59,688.34	317,365.31	20,788,26	2,367,335.84	2,705,489.41
Kansas	15,000.00	15,000.00	60,000.00	53,057.23	64,482.24	19,526.92	227,066.39	9,970.66	1,323,830.21	1,560,867.26
Kentucky	15,000.00	15,000.00	60,000.00	93,378.88	114,798.45	6,900.00	305,077.33		763,200.76	1,068,278.09
Louisiana	15,000.00	15,000.00	60,000.00	60,813.78	78,146.78	20,050.00	249,010.56		1,533,876.61	1,782,887.17
Maine	15,000.00	15,000.00	60,000.00	22,270.68	36,916.75	22,900.00	172,087.43	7,500.00	288,349.03	467,936.46
Maryland	15,000.00	14,985.00	60,000.00	36,488.62	45,794.36	19,750.00	192,017.98	6,400.76	656,806.87	855,225.61
Massachusetts	15,000.00	15,000.00	60,000.00	36,698.19	41,538.49	12,411.60	180,648.28	3,089.49	493,789.78	677,527.55
Michigan	15,000.00	15,000.00	60,000.00	93,777.64	100,436.14	20,147.54	304,361.32	35,139.85	1,500,562.27	1,840,063.44
Minnesota	15,000.00	15,000.00	60,000.00	68,128.03	90,783.35	39,790.00	288,701.38		2,171,837.86	2,460,539.24
Mississippi	15,000.00	15,000.00	60,000.00	80,016.75	114,584.58	43,655.00	328,256.33	29,269.81	1,289,895.75	1,647,421.89
Missouri	15,000.00	15,000.00	60,000.00	78,849.57	101,165.33	24,400.00	294,414.90	7,500.00	748,630.05	1,050,544.95
Montana	15,000.00	15,000.00	60,000.00	18,004.00	34,588.79	26,069.88	168,662.67		889,567.70	1,058,230.37
Nebraska	15,000.00	15,000.00	60,000.00	41,343.56	56,827.93	18,100.00	206,271.49		1,203,192.61	1,409,464.10
Nevada	15,000.00	15,000.00	60,000.00	3,435.49	21,930,44	8,400.00	123,765.93		71,961.72	195,727.65
New Hampshire	15,000.00	15,000.00	60,000.00	11,363.43	27,685.65	9,500.00	138,549.08		120,018.02	258,567.10
New Jersey	15,000.00	15,000.00	60,000.00	32,575.43	41,113.40	24,591.16	188,279.99	5,762.97	1,483,312.52	1,677,355.48
New Mexico	15,000.00	15,000.00	60,000.00	17,027.28	34,608.70	21,800.00	163,435.98		478,370.75	641,806.73

New York:										
Cornell	13,485.45	13,494.62	53,864.12	97,003.15	90,534.55	42,286.44	310,668.33	9,556.83	3,062,956.67	3,383,181.83
State	1,499.72	1,500.00	5,987.67	10,778.04	10,080.79	----------	29,846.22	4,962.78	965,709.95	1,000,518.95
North Carolina	15,000.00	15,000.00	60,000.00	135,186.64	155,586.12	34,900.00	415,672.76	391.47	1,598,262.20	2,014,326.43
North Dakota	15,000.00	15,000.00	60,000.00	26,670.28	43,717.63	2,650.00	163,037.91	----------	718,365.92	881,403.83
Ohio	15,000.00	15,000.00	60,000.00	118,853.05	120,920.85	20,100.00	349,873.90	12,188.65	1,624,872.88	1,986,935.43
Oklahoma	15,000.00	15,000.00	60,000.00	63,847.68	74,538.19	13,950.00	242,335.87	----------	1,167,441.80	1,409,777.67
Oregon	15,000.00	15,000.00	60,000.00	35,230.21	48,229.16	27,900.00	201,359.37	5,253.97	1,936,427.13	2,143,040.47
Pennsylvania	15,000.00	15,000.00	60,000.00	155,317.78	129,669.28	29,300.00	404,287.06	----------	1,170,756.20	1,575,043.26
Puerto Rico	15,000.00	14,244.39	59,626.32	65,728.69	106,882.93	3,316.22	264,798.55	2,996.56	833,418.67	1,101,213.78
Rhode Island	15,000.00	14,990.32	60,000.00	6,257.12	23,065.89	24,700.00	144,013.33	----------	123,127.03	267,140.36
South Carolina	15,000.00	15,000.00	60,000.00	68,111.24	88,128.77	21,505.00	267,745.01	----------	724,057.69	991,802.70
South Dakota	15,000.00	15,000.00	60,000.00	26,510.78	43,240.61	11,400.00	171,151.39	----------	451,967.81	623,119.20
Tennessee	15,000.00	15,000.00	60,000.00	92,293.90	116,613.40	27,990.00	326,897.30	9,007.50	679,007.53	1,014,912.33
Texas	15,000.00	15,000.00	60,000.00	150,461.58	155,684.35	64,290.00	460,435.93	11,412.21	2,730,428.49	3,202,276.63
Utah	15,000.00	15,000.00	60,000.00	12,499.09	29,967.64	35,740.00	168,206.73	----------	603,101.43	771,308.16
Vermont	15,000.00	15,000.00	60,000.00	12,884.06	29,533.54	11,188.29	143,605.89	1,613.07	85,592.25	230,811.21
Virginia	15,000.00	15,000.00	60,000.00	88,612.55	99,573.28	20,050.00	298,235.83	----------	951,989.47	1,250,225.30
Washington	15,000.00	15,000.00	60,000.00	43,950.86	54,859.98	41,708.00	230,518.84	9,009.59	2,062,214.31	2,301,742.74
West Virginia	15,000.00	15,000.00	60,000.00	65,794.28	72,053.79	26,297.38	254,145.45	2,500.00	389,910.76	646,556.21
Wisconsin	15,000.00	15,000.00	60,000.00	73,259.15	87,745.49	41,808.79	292,813.43	5,040.21	2,823,830.00	3,121,683.64
Wyoming	15,000.00	15,000.00	60,000.00	7,662.93	26,032.07	17,150.00	140,845.00	----------	464,279.96	605,124.96
Total	764,904.90	764,092.50	3,046,481.44	2,862,837.69	3,587,179.86	1,239,947.57	12,265,443.96	265,495.57	61,970,921.10	74,501,860.63

TABLE 13.—*Summary, by classification of expenditures, of the experiment stations for the year ended June 30, 1953*

Account	Hatch Act	Adams Act	Purnell Act	Bankhead-Jones Act, title I			Total	Contractual Federal funds, Agricultural Marketing Act, title II	Non-Federal funds	Grand total
				Sec. 5	Secs. 9 (b) 1 and 9 (b) 2	Sec. 9 (b) 3				
01 Personal services	$614,634.93	$687,951.11	$2,655,099.15	$2,425,931.52	$2,915,768.89	$844,701.59	$10,144,087.19	$196,378.47	$39,730,070.50	$50,070,536.16
02 Travel	23,725.34	7,271.25	53,194.87	40,694.62	103,934.06	104,806.03	333,626.17	19,063.97	1,545,833.15	1,898,523.29
03 Transportation of things	460.91	658.02	1,870.62	2,340.21	4,030.36	2,081.30	11,441.42	262.05	190,634.59	202,338.06
04 Communication service	2,785.85	414.08	2,777.21	2,714.76	4,796.66	2,867.72	16,356.28	842.42	420,209.84	437,408.54
05 Rents and utility services	2,178.33	1,557.19	7,851.76	6,458.02	13,070.92	4,535.97	35,652.19	954.29	1,048,851.75	1,085,458.23
06 Printing and reproduction	42,034.32	----------	22,255.34	12,718.01	25,082.33	15,873.68	117,963.68	4,318.88	747,551.47	869,834.03
07 Other contractual services	6,991.19	5,703.36	32,016.72	35,805.99	66,634.04	43,587.16	190,738.46	11,874.39	2,586,018.02	2,788,630.87
08 Supplies and materials	38,132.96	40,694.72	180,612.16	246,589.56	308,995.76	140,045.71	955,070.87	20,657.65	10,458,143.33	11,433,871.85
09 Equipment	31,250.05	16,856.86	69,180.39	74,264.41	127,769.86	74,760.55	394,082.12	11,064.64	3,562,637.87	3,967,784.63
10 Lands and structures (contractual)	347.46	404.10	12,357.89	6,100.98	8,307.51	5,414.14	32,932.08	----------	1,335,385.24	1,368,317.32
11 Contributions to retirement	2,140.63	2,399.87	8,625.12	7,815.63	7,841.49	1,165.37	29,988.11	----------	308,737.83	338,725.94
15 Taxes and assessments	222.93	181.94	640.21	1,403.98	947.98	108.35	3,505.39	78.81	36,847.51	40,431.71
Total	764,904.90	764,092.50	3,046,481.44	2,862,837.69	3,587,179.86	1,239,947.57	12,265,443.96	265,495.57	61,970,921.10	74,501,860.63

TABLE 14.—*Expenditures and allotments under the Agricultural Marketing Act, title II, for the year ended June 30, 1953*

Station	Expenditures												Unexpended	Funds available [1]
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and reproduction	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Taxes and assessments	Total expenditures		
California	$8,551.84	$2,610.84						$537.32				$11,700.00		$11,700.00
Connecticut (Storrs)	4,260.00	397.94				$291.00		96.46	$76.36			5,121.76	$79.98	5,201.74
Florida	4,500.21											4,500.21	1,111.75	5,611.96
Georgia	13,439.73	1,562.45	$2.39				$403.09	660.55	383.89			16,452.10		16,452.10
Hawaii	3,155.88	1,846.37		$66.00		1,231.00	100.15	11.10				6,410.50	590.73	7,001.23
Illinois	3,295.61	658.27						55.43				4,009.31	1,975.89	5,985.20
Indiana	13,238.88	1,365.55	13.18	8.40			753.04	1,207.73	1,360.27			17,947.05	600.17	18,547.22
Iowa	16,877.75	930.34	3.27	7.00		94.56		998.39	1,876.95			20,788.26	1,048.57	21,836.83
Kansas	9,327.80	77.35				90.87	232.94	162.89			$78.81	9,970.66	31.79	10,002.45
Maine	3,601.98	799.19	195.38	165.42		231.74	423.42	1,121.67	961.20			7,500.00		7,500.00
Maryland	4,642.16	805.22				8.35	945.03					6,400.76	113.21	6,513.97
Massachusetts	2,931.82	157.67										3,089.49	910.51	4,000.00
Michigan	27,628.98	630.43	2.96	6.50	$4.00	591.33	4,702.25	745.65	827.75			35,139.85	4,224.55	39,364.40
Mississippi	18,728.52	990.72	6.47	428.48	900.29	995.76	1,257.69	2,464.92	3,496.96			29,269.81		29,269.81
Missouri	5,830.30	103.46	2.84	47.45		7.42	315.83	1,139.03	53.67			7,500.00		7,500.00
New Jersey	4,278.05						174.11	1,310.81				5,762.97	1,496.84	7,259.81
New York:														
Cornell	5,206.72	1,557.18				776.85	25.34	1,262.24	728.50			9,556.83	9.87	9,566.70
State	1,557.74	199.43					1,661.29	712.93	831.39			4,962.78	61.69	5,024.47
North Carolina	391.47											391.47		391.47
Ohio	9,400.12	757.91						1,716.72	313.90			12,188.65	971.35	13,160.00
Oregon	4,554.40	475.17		58.90			16.60	24.61	124.29			5,253.97	1,746.03	7,000.00
Puerto Rico	2,996.56											2,996.56	4,140.44	7,137.00
Tennessee	5,056.45	479.17	10.00	12.58			6.00	3,413.79	29.51			9,007.50		9,007.50
Texas	9,603.29	224.41		40.69			458.79	1,085.03				11,412.21	2,618.92	14,031.13
Vermont	1,613.07											1,613.07	886.93	2,500.00
Washington	8,066.53	913.06		1.00			29.00					9,009.59		9,009.59
West Virginia	1,000.00	1,500.00										2,500.00		2,500.00
Wisconsin	2,642.61	21.84	25.56		50.00		369.82	1,930.38				5,040.21	13,906.52	18,946.73
Total	196,378.47	19,063.97	262.05	842.42	954.29	4,318.88	11,874.39	20,657.65	11,064.64		78.81	265,495.57	36,525.74	302,021.31

[1] Include allotments from the appropriation for fiscal year 1953 plus unexpended balances of allotments from appropriations for fiscal year 1952.

SUBJECT INDEX

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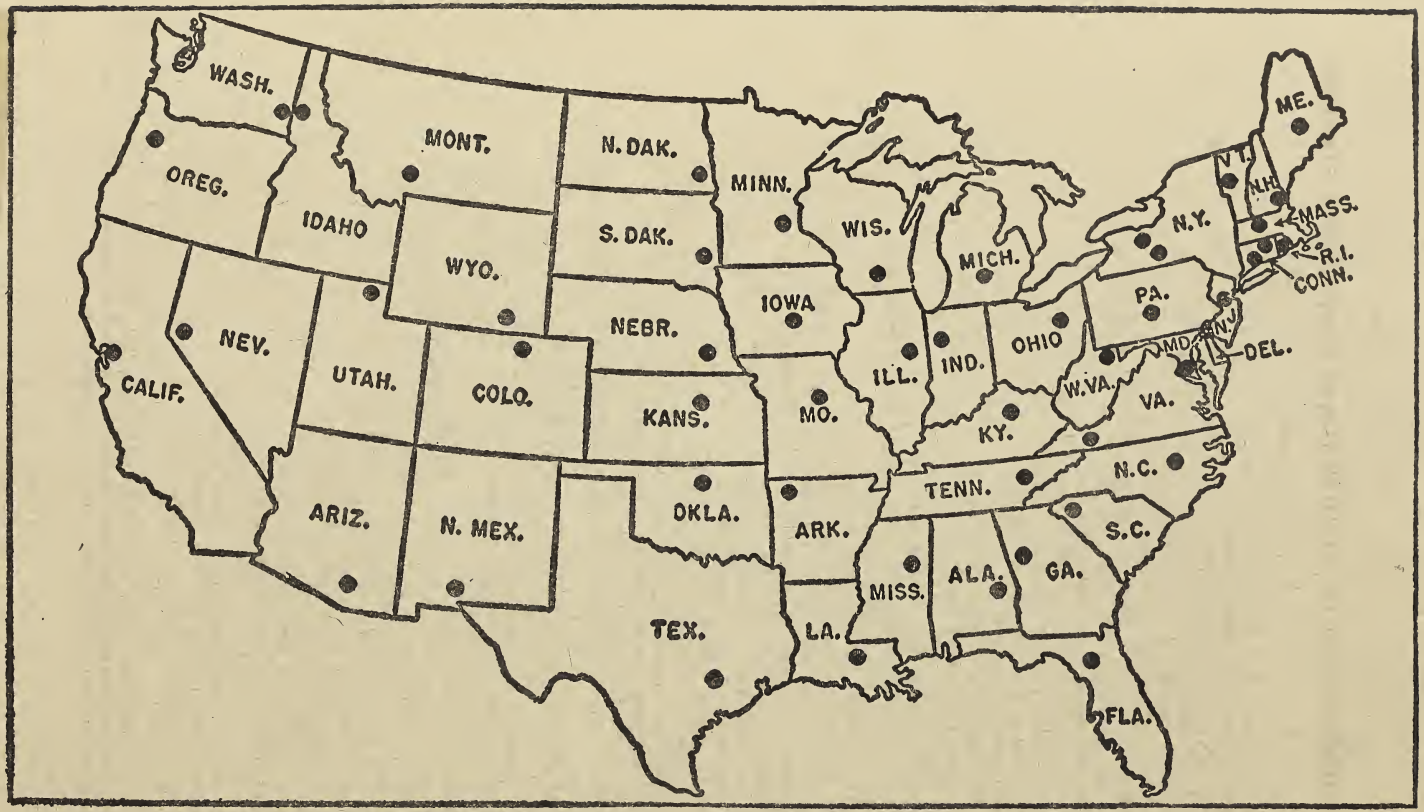
NOTE.—The full official titles, locations, and personnel of the agricultural experiment stations will be found in the list of Workers in Subjects Pertaining to Agriculture in Land-Grant Colleges and Experiment Stations, published by the United States Department of Agriculture.



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